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ORIGINAL ARTICLES.

I.—Eminent Living Geologists:

Wilfrid Hudleston Hudleston, J.P., M.A., F.R.S., F.L.S., F.G.S., F.C.S., etc.,

(WITH A PORTRAIT,[1] PLATE XIV.)

GEOLOGY is a science which owes, not only its inception, but its continued existence largely to its non-professional disciples and lovers. In fact, of the two classes existing at the present time, the 'amateur' and the 'professional,' it would by no means be difficult to show that the former gave birth to the latter, and that some of the best living professional geologists have been recruited from the ranks of the amateur class. To a small band of early amateurs we are indebted for the foundation alike of the Geological Society and the Geological Survey in this country.

At the beginning of the last century—indeed, during the first half of it—geological teachers were scarce, and Natural Science had not attained a recognised position in our public schools. But for the early training received from William Smith (known as "the father of English geology") we might never have heard of his distinguished nephew, Professor John Phillips. Nor can we omit to recall the illustrious names of Hutton, Macculloch, Greenough, Conybeare, Fitton, Broderip, Darwin, Godwin-Austen, Fisher, Sorby; with Buckland, Sedgwick, Phillips, Forbes, Morris, Prestwich, Green, Bonney, and Nicholson, among our past University Lecturers; and De la Beche, Griffith, Portlock, Murchison, Ramsay, Jukes, and Geikie, as leaders of Surveys; and Hutton, Lyell, Poulett-Scrope, Huxley, Geikie, and others, among our classical geological writers, most of whom studied geology and palæontology in their early years as amateurs, and several of whom remained so all their lives.

Now, all is changed. Owing to the numerous centres for public instruction and the introduction of Natural Science teaching in our Universities, a large number of fully trained geological students is

[1] The portrait of Mr. Hudleston is reproduced by kind permission of "The Biographical Press Agency," 16, Henrietta Street, Strand, W.C.—Ed. Geol. Mag.

being turned out annually "for home and colonial consumption," and we need no longer rely altogether upon the casual crop of young men having an innate love of the science, which may prompt them to take up geology because they are interested in it. Many, indeed, nowadays may be "called," but possibly not all those "chosen" have a genuine love for the science they affect.

It is pleasant to record the scientific services of one who, while he belongs to the non-professional class of geologists, has yet achieved a very large amount of most excellent work, both in geology and palæontology, and has, by his merit, won for himself the blue ribbon of the science. Wilfrid Hudleston Hudleston (formerly Simpson) was the son of Dr. John Simpson, of Knaresborough, who married Elizabeth Ward, heiress of the Hudlestons of Cumberland, and by letters-patent assumed the name of Hudleston in 1867. Wilfrid, the eldest son, was born at York on June 2nd, 1828, being the descendant of three generations of Yorkshire 'medicine-men.' From 1831 to 1834 his parents resided at Harrogate, where he remembers meeting his first playfellow, Henry Clifton Sorby—afterwards a distinguished geologist, an LL.D., F.R.S., and President (1878–80) of the Geological Society of London—then a schoolboy in the neighbourhood. Young Simpson received his early education at St. Peter's School, York, from which he was transferred to Uppingham School, and subsequently entered St. John's College, Cambridge, where he graduated B.A. in 1850. As a boy and an undergraduate he evinced no special predilection for geology beyond a strange boyish curiosity to know what the earth was made of. In his last term at Cambridge he attended Sedgwick's lectures, and was much impressed with the manner and appearance of that distinguished geologist. On leaving Cambridge he devoted some time to the study of the Law, and was called to the Bar in 1853, but never practised. A considerable portion of the twelve years 1850–1862 was spent in foreign travel in various parts of Europe and North Africa.

Mr. Simpson accompanied Professor Alfred Newton, of Cambridge, and Mr. John Wolley, in the pursuit of Ornithology, to Lapland, spending the Summer of 1855 in that country. He subsequently explored the Eastern Atlas, Algeria, in company with Canon Tristram and Mr. Osbert Salvin. Afterwards, more than twelve months were occupied in travels and collecting in Greece and Turkey. During this time attention was given to the physical and geological features of the various countries visited, but Ornithology occupied a foremost place.

From 1862 to 1867, his long period of distant travel being mostly over, Mr. Simpson began a special course of scientific studies, selecting more particularly Natural History and Chemistry. During this time he studied at Edinburgh under Playfair and Stephenson Macadam, and subsequently for three sessions at the Royal College of Chemistry in London under Hoffmann, Frankland, and Valentine. At that time he was undecided whether to take Chemistry or Geology as his principal subject, when an accident determined his studies in favour of the latter. Mr. Simpson had the good fortune to

meet Marshall Hall at Chamounix in the Summer of 1866, and on their return to England he was speedily introduced to many persons interested in geological science, of whom Professor John Morris may be regarded as the chief. There are still many who can recall the remarkable magnetic attraction of Morris over his pupils and associates, and this was just the kind of influence which Mr. Simpson, now become Mr. Wilfrid Hudleston, required to enlist him as a geological recruit and in due course to make him a "knight of the hammer" for the rest of his life. A close friendship was at once formed, which was only terminated by the death of Morris in 1886. In 1867 Mr. Simpson (a fortnight only before he changed his name to Hudleston) was elected a Fellow of the Geological Society of London, and four years later he became a member of the Geologists' Association.

About this period, 1867–71, Professor Morris was in the habit of extending his geological excursions far into the country, and out of this practice grew the improved excursions of the Geologists' Association, which, under various leading geologists, offered, without exception, the best instruction in geology which could be obtained, "*at the bed-side*"! Mr. Hudleston was not slow to profit by these excursions, and when he became Secretary in 1874 his interest was further enhanced by preparing reports on the various districts visited, some of which attain the dimensions of a respectable memoir. It was not until 1872 that he ventured on publication, and it may be noticed of many of his earlier papers that they have a decided bias towards chemical geology, in which subject he always took a deep interest. His papers on "The Yorkshire Oolites" (1873–8) and "The Corallian Rocks of England" (written in conjunction with Professor J. F. Blake, 1877) soon established his reputation as one of our leading geologists.

In 1881 Mr. Hudleston was elected President of the Geologists' Association, in which body he had already served the office of Secretary for three years, from 1874 to 1877, during which time, besides the duties of his office, he organised the excursions, prepared the reports, and carefully recorded the scientific work accomplished, earning for himself (said Mr. Carruthers) "the lasting gratitude of the Association" (see Annual Report, 1877, vol. v, p. 75). The Reports of Excursions directed by him are full of original observations, notably those relating to the Vale of Wardour (1881) and the West Riding of Yorkshire (1882). The cordial relations which have always existed between Mr. Hudleston and the Geologists' Association were further evinced in March, 1892, when an illuminated address of congratulation on his recent election to the chair of the Geological Society, signed by a numerous body of members, was presented to him by Professor Blake, then President of the Association.

Mr. Hudleston resided for many years in Cheyne Walk, Chelsea, but in 1883 he removed to Oatlands Park, Surrey. This rustication, however, interfered with his scientific engagements, and he again took up his residence in town, at 8, Stanhope Gardens, South

Kensington. In 1890 he married Miss Rose Benson, second daughter of the late William Heywood Benson, Esq., of Littlethorpe, near Ripon.

On the death of his old friend, Professor Morris, in 1886, Mr. Hudleston succeeded him as one of the Editors of the GEOLOGICAL MAGAZINE, to which, since 1879, he has been a frequent contributor.

He is a keen student of recent and fossil mollusca, and was one of the founders of the Malacological Society.

In 1886 accompanied by his friends Dr. Henry Woodward, F.R.S., and Mr. C. E. Robinson, Memb. Inst. C.E., Mr. Hudleston made some experimental dredgings, with the aid of a Brixham trawler and her crew, along the English Channel and in and near Torbay, for the purpose of studying marine mollusca and observing their living habitats; and in the following year he engaged a Grimsby steam-trawler and her crew, and, accompanied by Mr. C. E. Robinson and the late lamented Martin F. Woodward, of the Royal College of Science (second son of Dr. Henry Woodward), he spent three weeks in a dredging cruise in the English Channel to the west of Portsmouth and along the French coast.

In 1886 Mr. Hudleston became one of the Secretaries of the Geological Society of London, an office which he continued to hold until 1890. Following Sir Archibald Geikie, D.Sc., LL.D., F.R.S., Mr. Hudleston was in 1892 elected to fill the office of President, and during the two years in which he occupied the chair he delivered two important Addresses, dealing with the recent work of the Geological Society, which he passed critically in review, taking the papers on Tertiary and Secondary formations in 1893 and those on the Palæozoic and Fundamental rocks in 1894.

Three years later, in 1897, Mr. Hudleston was awarded the highest honour which the Council could bestow, the Wollaston Gold Medal of the Geological Society, in recognition of his valuable contributions to our knowledge, treating of chemical, mineralogical, palæontological, and stratigraphical geology. Special reference was made to his "Monograph on the Inferior Oolite Gasteropoda," which contained no less than 514 quarto pages of letterpress and 44 quarto plates of fossils. The labour involved in collecting, cleaning, and developing the Oolitic Gasteropoda procured for this work, all of which are now arranged in his private Museum in Stanhope Gardens, occupied Mr. Hudleston, with the co-operation of A. H. Bloomfield, Henry Keeping, B. Reynolds, Peter Cullen, and others, over a period of twenty years, fresh excavations having occasionally been made in quest of new species or to obtain better examples of those already known. In addition to this, some private collections, including those of Mr. S. S. Buckman and Mr. Darrel Stephens, were acquired by purchase. The Gasteropoda alone number many thousand specimens, carefully labelled and arranged, the 'types' being all specially marked. It is not too much to say that this was in all respects a model of what a monograph should be. No previous author had taken such pains to verify in the field the horizons from which the

fossils had been obtained, nor studied more fully the Continental types figured from equivalent strata.

Early in January, 1895, Mr. Hudleston, accompanied by his wife and his friend Professor J. F. Blake, F.G.S., left London for Bombay, where they arrived towards the end of the month. After leaving Professor Blake duly installed as organizing Curator of the Museum at Baroda, to which he had just been appointed, Mr. Hudleston continued his journey towards the north-west frontier of India. The geological results of this expedition are embodied in the second part of his paper "Notes on Indian Geology," read before the Geologists' Association during the presidency of the late General C. A. McMahon, December, 1895 (see Proc. Geol. Assoc., xiv, pt. 6, February, 1896), who himself contributed an appendix on some of the rock-specimens collected. After making a rush for Simla, which is by no means an agreeable place in February, Mr. and Mrs. Hudleston proceeded across the Punjab to the banks of the Jhelum. Here they had an opportunity of ascending Mt. Tilla, the eastern extremity of the Salt Range, and thence transferred their base of operations to Rawal Pindi, whence Jamrood, Abbotabad, Murree, and finally Srinagar itself were visited.

Mr. Hudleston has been invited to preside over or take part in the Councils and Committees of numerous scientific Societies. He was elected President of the Devonshire Association for the Advancement of Science, Literature, and Art, of the Yorkshire Naturalists' Union, and of the Malton Field Naturalists' Society; and has for some years past acted as a Vice-President of the Dorset Natural History Field Club. He has been a member of the Council of the Royal Geographical Society, and was President of the Geological Section of the British Association at Bristol in 1898.

Quite recently Mr. Hudleston achieved an excellent piece of field geology by investigating the structure of Creechbarrow-in-Purbeck (see GEOL. MAG., 1902, pp. 241–256, and 1903, pp. 149–154, 197–203), which affords an object-lesson for younger hammerers to take pattern by.

The accompanying list of Mr. Hudleston's more important papers will best attest the energy and ability of their author, and the pleasure which he still continues to take in all the scientific questions of the day.

Of these 58 memoirs and papers, extending over a period of 32 years, the last appeared so recently as July of the present year (see GEOLOGICAL MAGAZINE, No. 481, pp. 337–382), and deals with "the Tanganyika problem," and is a most valuable contribution to, as well as a criticism of, Mr. J. E. S. Moore's recently published work on this subject. Indeed, we have the testimony of Professor Cornet himself upon this point. In the first place Mr. Hudleston enters upon a critical examination of the peculiarly marine-looking gasteropod shells which are thought by Mr. Moore to be homœomorphic with certain shells from beds of the Inferior Oolite of Western Europe, and are thus inferentially regarded as descendants of those forms. Mr. Hudleston

finds that the evidence of an ancestral connection between certain of these halolimnic genera (namely, *Typhobia*, *Bathanalia*, *Limnotrochus*, *Chytra*, *Paramelania*, *Bythoceras*, *Tanganyicia*, *Spekia*, and *Nassopsis*) is not nearly so strong as was anticipated from the inferences already drawn by Mr. Moore; nevertheless, a fairly good *primâ facie* case for the *originally marine* origin of these exceptional organisms has been made out by Mr. Moore, but the supposed connection, in long ages past, of Lake Tanganyika with an arm of the Jurassic sea is held to be highly improbable, if not wholly impossible. In the second place Mr. Hudleston has collected together much of the scattered evidence as to the geological history of this vast Lake-area, some of which had escaped Mr. Moore's notice, especially the works of Professor Cornet of Mons, M. Barrat, and Mr. Molyneux, etc.

From a general consideration of the case it is apparent that the great longitudinal faults, folds, furrows, or "graben," as they are named, in which Tanganyika and the other lakes lie, are *not older than the Tertiary period*, and cannot therefore have formed a refuge in Secondary times for the remnant of an old Jurassic *marine* fauna in its hollows. Indeed, it seems probable that *a large portion* of the elevated interior region (composed of Archæan, Granitoid, and other ancient rocks) may have been a land-area from Triassic times or even earlier.

A magistrate and a landed proprietor in Dorsetshire and the West Riding of Yorkshire, Mr. Hudleston is a keen sportsman, loving both fishing and shooting, and divides his time between his country house at West Holme, near Wareham, Dorset, and his town residence, and still enjoys the meetings of the Geological, the Geographical, and other Societies, in the work of which he feels the same enthusiasm as of old.

LIST OF GEOLOGICAL PAPERS, ETC., BY WILFRID H. HUDLESTON.

1872. (With Mr. F. G. H. Price) "Excavations on the Site of the New Law Courts": Proc. Geol. Assoc., vol. iii, p. 43.
1873–8. "The Yorkshire Oolites": Proc. Geol. Assoc., vol. iii, p. 283; vol. iv, p. 353; vol. v, p. 407.
1874. Reports of Excursions to Oxford and Northamptonshire: Proc. Geol. Assoc., vol. iv, pp. 91 and 123.
1875. Reports of Excursions to the Isle of Thanet, to Charnwood Forest, and to East Yorkshire: Proc. Geol. Assoc., vol. iv, pp. 254, 307, and 326.
1875. Appendix. [On the Occurrence of Phosphates in Cambrian Rocks.] Quart. Journ. Geol. Soc., vol. xxxi, p. 376.
1876. Reports of Excursions to the Medway, to Reading, and to Swindon–Faringdon: Proc. Geol. Assoc., vol. iv, pp. 503, 519, 543.
1877. (With the Rev. J. F. Blake) "The Corallian Rocks of England": Quart. Journ. Geol. Soc., vol. xxxiii, p. 260.
1877. (With Mr. Davey) Report of an Excursion to Wantage: Proc. Geol. Assoc., vol. v, p. 137.
1877. Appendix. [Chemical Composition of some Lizard Rocks.] Quart. Journ. Geol. Soc., vol. xxxiii, p. 924.
1878. Report of an Excursion to Chipping Norton: Proc. Geol. Assoc., vol. v, p. 378.
1878. "Gneiss Rocks of the North-West Highlands": Proc. Geol. Assoc., vol. vi, p. 47.
1879. Review of Daubrée's "Géologie expérimentale": Geol. Mag., Dec. II, Vol. VI, p. 421.

1879. Review of Sterry Hunt's Chemical and Geological Essays: Geol. Mag., Dec. II, Vol. VI, p. 554.
1880. Reports of Excursions to Oxford and Aylesbury: Proc. Geol. Assoc., vol. vi, pp. 338 and 344.
1880–1. "Corallian Gasteropoda of Yorkshire": Geol. Mag., Dec. II, Vol. VII, p. 241; Vol. VIII, p. 119.
1881. Report of an Excursion to Salisbury, Stonehenge, etc.: Proc. Geol. Assoc., vol. vii, p. 134.
1881. "On the Geology of the Vale of Wardour": Proc. Geol. Assoc., vol. vii, p. 161.
1881. Review of Wallace's "Island Life": Geol. Mag., Dec. II, Vol. VIII, p. 84.
1881. "Gasteropoda of the Portland Rocks": Geol. Mag., Dec. II, Vol. VIII, p. 385.
1881. Notes on the Geology of Keswick, and Report of an Excursion to the Lake District: Proc. Geol. Assoc., vol. vii, pp. 213 and 236.
1881. Presidential Address on "Deep Sea Investigation": Proc. Geol. Assoc., vol. vii, p. 245.
1882–5. "Gasteropoda of the Oxfordian and Lower Oolites of Yorkshire": Geol. Mag., Dec. II, Vol. IX, pp. 145, 193, and 245; Dec. III, Vol. II, pp. 49, 121, 151, 201, and 252.
1882. Review of King and Rowney's work on the so-called *Eozoon Canadense*: Geol. Mag., Dec. II, Vol. IX, p. 231.
1882. Report of an Excursion to the Isle of Purbeck: Proc. Geol. Assoc., vol. vii, p. 377.
1882. Report of an Excursion to the West Riding of Yorkshire: Proc. Geol. Assoc., vol. vii, p. 420, and Proc. Yorks. Geol. Soc., vol. for 1882, p. 113.
1882. "First Impressions of Assynt": Geol. Mag., Dec. II, Vol. IX, p. 390.
1882. Presidential Address on "The Geology of Palestine": Proc. Geol. Assoc., vol. viii, p. 1, and Proc. Yorks. Geol. Soc., vol. for 1883, p. 174.
1883. "Notes on the Diamond Rock of South Africa": Proc. Geol. Assoc., vol. viii, p. 65.
1883. "On a recent Hypothesis with respect to the Diamond Rock of S. Africa": Min. Mag., vol. v, p. 199.
1883. "On a Collection of Fossils and Rock-specimens from West Australia": Quart. Journ. Geol. Soc., vol. xxxix, p. 582.
1883. Review of Barrois' "Geology of the Asturias, etc.": Geol. Mag., Dec. II, Vol. X, p. 273.
1884. Review of Sterry Hunt's "Geological History of the Serpentines": Geol. Mag., Dec. III, Vol. I, p. 276.
1884. "Mollusca from South Australia": Geol. Mag., Dec. III, Vol. I, p. 339.
1884. Presidential Address to the Malton Field Naturalists' Society; Malton, 1885.
1885. "Further Notes on the Geology of Palestine": Proc. Geol. Assoc., vol. ix, p. 77. On p. 101 of this volume the analogy between the Jordan Valley fissure and the East African fissure lakes, such as L. Baringo, is suggested.
1885. (With Mr. H. B. Woodward) Report of an Excursion to Sherborne and Bridport: Proc. Geol. Assoc., vol. ix, p. 187.
1886–7. "On a Recent Section through Walton Common," and further notice: Quart. Journ. Geol. Soc., vol. xlii, p. 147, and vol. xliii, p. 443.
1887–96. Monograph of the Gasteropoda of the Inferior Oolite: Palæontographical Society.
1887. Report of an Excursion to Aylesbury: Proc. Geol. Assoc., vol. x, p. 166.
1889. Report of an Excursion to Weymouth: Proc. Geol. Assoc., vol. xi, p. 49.
1889. "Geological History of Iron Ores" (being the Presidential Address delivered to the Yorkshire Naturalists' Union at Sheffield in November, 1888): Proc. Geol. Assoc., vol. xi, p. 104.
1889. Presidential Address to the Devonshire Association (Tavistock): Trans. Dev. Assoc., vol. xxi, p. 25, and Geol. Mag., Dec. III, Vol. VI, pp. 500 and 558.
1890. "Mollusca from South Australia": Geol. Mag., Dec. III, Vol. VII, p. 241.
1892. (With Mr. E. Wilson) "A Catalogue of British Jurassic Gasteropoda": Dulau & Co.

1893–4. Two Presidential Addresses to the Geological Society of London on "Some Recent Work of the Society": Quart. Journ. Geol. Soc., vol. xlix, Proc., p. 65, and vol. L, Proc., p. 58.
1895. "Notes on Indian Geology, including a Visit to Kashmir": Proc. Geol. Assoc., vol. xiv, p. 226.
1896. (With Mr. Monckton) Report of an Excursion to Swanage, Corfe Castle, Kimeridge, etc.: Proc. Geol. Assoc., vol. xiv, p. 312.
1897. Review of Dr. C. Irons' "Life and Work of Dr. Croll": Geol. Mag., Dec. IV, Vol. IV, p. 71.
1898. Address to the Geological Section of the British Association at Bristol: Report (Trans. Sect. C), p. 852, and Geol. Mag., Dec. IV, Vol. V, p. 458.
1899. "On the Eastern Margin of the North Atlantic Basin": Geol. Mag., Dec. IV, Vol. VI, pp. 97 and 145.
1901. (With others) "A Day in West Purbeck": Proc. Dorset Field Club, vol. xxii, p. liv.
1902. (With General C. A. McMahon) "Fossils from the Hindu Khoosh": Geol. Mag., Dec. IV, Vol. IX, pp. 3 and 49.
1902. "Creechbarrow: an Essay in Purbeck Geology": Proc. Dorset Field Club, vol. xxiii, p. 146. See also Geol. Mag., Dec. IV, Vol. IX, p. 241, and Vol. X, pp. 149, 197.
1902. Review of Bertrand's "Panama" (a memoir published in 1899): Geol. Mag., Dec. IV, Vol. IX, p. 419.
1903. "Chesil Beach": Proc. Dorset Field Club, vol. xxiv, p. 1.
1903. Review of Tempest Anderson's "Volcanic Studies": Geol. Mag., Dec. IV, Vol. X, p. 160.
1904. Review of Messrs. Freshfield & Garwood's "Round Kanchenjunga": Geol. Mag., Dec. V, Vol. I, p. 74.
1904. "On the Origin of the Marine (Halolimnic) Fauna of Lake Tanganyika": Trans. Victoria Inst. for 1904, and as a Supplement in the July number of the Geol. Mag., Dec. V, Vol. I.

Mr. Hudleston is also the author of a considerable number of reviews and notices, some of which have appeared in the Annals and Magazine of Natural History, and others in the Geological Magazine, for the most part anonymously.

II.—Note on a Palæozoic *Cypridina* from Canada.

By Professor T. Rupert Jones, F.R.S., F.G.S.

In the Annals and Magazine of Natural History, ser. VII, vol. i (1898), pp. 333–334, pl. xxvii, a numerous series of fossil Ostracoda, with bivalved carapaces, having more or less resemblance to those of *Cypridina*, were described and figured. The specimens selected had been collected by various observers in different regions; and comprised two from the Tertiary of France, two from the Cretaceous of Belgium, one from the Permian of Durham, seven from the Carboniferous of Britain, three from the Devonian of Devon, three from the Upper Silurian and two from the Lower Silurian (Ordovician) of distant regions. References were made to several allied Palæozoic forms; and one other species from the Carboniferous of North America (Ulrich) and two from the Upper Silurian of Scania (Moberg) ought to have been mentioned.

We have now to notice another old Cypridinal form (the internal cast of a left valve), probably of Ordovician age. It has come to hand from Colonel C. C. Grant, of Hamilton, Ontario, Canada, who exposed it in breaking up some blocks of limestone, probably belonging to the Trenton series, from a 'glacial drift' at Wenoma, on the shore of Lake Ontario, not far from Hamilton.

This limestone is largely composed of a small gregarious variety of *Isochilina Ottawa*, Jones (see GEOL. MAG., July, 1903, pp. 300–304); and in this condition it resembles other specimens collected by Colonel Grant, and sent by him to the British Museum.

The particular specimen under notice is shown in Fig. 1. It approaches in lateral outline to *Cypridina brevimentum*, Jones, Kirkby, and Brady (Foss. Entom. Carbonif., pt. i, 1874, p. 16, pl. ii, figs. 15–19, especially fig. 15*a*). It differs, however, from that species in the following particulars:—

It is more definitely oblong; straight on the back, with its postero-dorsal angle, and not the postero-ventral part, projecting. The hook or hood is narrower and sharper than in *C. brevimentum*; attenuated partly by loss of substance.

The notch below is deeper than in the figures quoted; and it has a bold outline with an ogee curve. The cast itself has suffered a slight damage by having lost some of its convex surface, and the middle part of both its ventral and its dorsal edge, when it was being detached from the block. With the above-mentioned distinctive characters we may regard it provisionally as a separate species, with the name of *Cypridina antiqua*, sp. nov.

FIG. 1.—*Cypridina antiqua*, T. R. Jones, sp. nov. Magn. 3 diam. Of Ordovician age? From Glacial Dritt (limestone of the Trenton series), Wenoma, on the shore of Lake Ontario, near Hamilton, Canada.

This internal mould of a left valve (Fig. 1) is somewhat decorticated across the middle of its convexity. The cast consists of dark-grey, fine-grained, and slightly micaceous mudstone, distinct from the limestone to which it is attached. It measures 15 millimetres in length and 10 in height (from dorsal to ventral edge).

III.—NOTE ON A SMALL ANTICLINE IN THE GREAT OOLITE SERIES AT CLAPHAM, NORTH OF BEDFORD.[1]

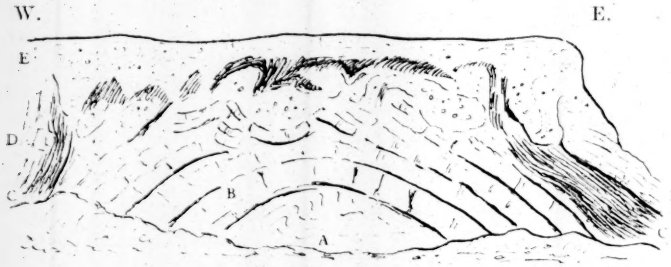
By HORACE B. WOODWARD, F.R.S.

IN the broad Alluvial tract which borders the Ouse between Oakley and Clapham, north of Bedford, there is a gravel-pit in which a small anticline of the Great Oolite was abruptly encountered amidst the regularly stratified river-deposits. The pit is situated immediately north of the Oakley road and east of the Midland Railway.

The trend of the fold was N.N.W. and S.S.E., and the upraised strata consisted of Great Oolite Limestone and Clay, with bordering portions of Cornbrash, and probably also of Kellaways Beds. The ridge was exposed over a space about 20 yards in length, and the arch of Oolite strata, about 18 yards in breadth, was clearly displayed in a transverse section, flanked on either side by undisturbed beds

[1] Read before the Meeting of the British Association, Cambridge, August, 1904.

of river gravel and sand; the whole being opened up to a depth of 10 or 12 feet. Prior to the excavation there was no indication of the disturbed strata, although they actually reached the surface. The arch, however, was coated with Great Oolite Clay, which had been disarranged superficially and intermixed with gravel.



Section at Clapham, north of Bedford.

		feet.
Soil and gravel, etc.	E. Brown loam and stony loam and clay, and irregular pockets of brown and white gravel intermixed with C.	
Cornbrash.	D. Marly and flaggy limestone with *Ostrea flabelloides* ...	2
Great Oolite Clay.	C. Dark-blue clay	up to 3
Great Oolite Limestone.	B. Grey limestones	5 to 6
	A. Marly clay with *Ostrea Sowerbyi*. Marls and limestones (seen in pit, further south).	

The Great Oolite Clay, less disturbed on the flanks of the anticline, was thinner than that exposed by the Bedford waterworks, south of Clapham: an attenuation possibly resulting from the flexure. The limestones below were bent into an arch and slightly broken, while the lowest strata of marly clay with *Ostrea Sowerbyi* were much squeezed up. The Cornbrash, a flaggy limestone with *Ostrea flabelloides*, was seen at the base of the pit on the eastern side of the arch, and traces of sands (resembling those of the Kellaways Beds) were noticeable a little distance away on the western side.

The adjacent deposit, a white gravel, with brown decalcified portions resting irregularly on a 'piped' surface of it, was made up mainly of Oolite limestone, together with rolled Oxfordian and other fossils, quartz, quartzite, jasper, flint pebbles, and subangular and angular flints. It yielded also a partially decomposed block of rhomb-porphyry, evidently derived from the Boulder-clay which covers the higher grounds; and the occurrence of this Scandinavian rock is of interest, as hitherto no example has been recorded south of Norfolk.[1] A portion of a molar of *Elephas primigenius* was likewise obtained from the gravel—the age of which is evidently subsequent to the Boulder-clay of the district.

With regard to the age and origin of the small anticline, there is no particular evidence. It must have been formed prior to the

[1] See Professor P. F. Kendall: "Eighth Report of Committee on Erratic Blocks of the British Isles," Rep. Brit. Assoc. for 1903.

accumulation of the gravel, and unfortunately little more can be said with confidence.

The Ouse follows a serpentine course from the neighbourhood of Sharnbrook to Bedford, a distance in a direct line of rather more than six miles, and all the way the bed of the river lies practically on the Great Oolite Series—the normal dip being locally counteracted by slight undulations and occasional faults. It is possible that the small anticline may be connected with these earth-movements, but as its direction is contrary to that of the gentle folds above noted, this supposition does not appear to be probable.

Again, it might be surmised that the flexure was purely local and superficial, that perhaps glacial action had been the cause; but of this there is no distinct evidence either for or against. All that can be reasonably inferred is that the superincumbent portions of Kellaways Beds and Cornbrash—the latter but a thin band of rock in the immediate district—had been planed off the dome prior to or during the period of maximum glaciation, when the Boulder-clay which crowns the adjacent plateau was laid down. The erosion of the softer strata flanking the anticline was perhaps due to the action of the river, if not to torrential waters in the later phases of the Glacial period; and possibly the arch of Oolite limestones stood out as a low ridge or islet in the broad course of the river, until the inequality was levelled up by the accumulation of the valley deposits.

IV.—*Linthia oblonga* (Orbigny) from Sinai.

(PLATE XV.)

By R. Bullen Newton, F.G.S.

In a collection of Cretaceous fossils from Sinai obtained by Mr. T. Barron, F.G.S., which has been entrusted to me for determination by the Geological Survey of Egypt, I found several specimens of *Linthia oblonga*, a form of Echinoid which appears to have escaped the attention of modern writers on the palæontology of the Sinai Peninsula. In tracing the history of this species it is ascertained that d'Orbigny first figured and described it under the genus *Periaster* during the year 1856 in the Pal. Française Terr. Crétacés Échinodermes, pl. 900, pp. 275, 276, where it is referred to as having been collected by M. Lefébvre at Mount Garèbe, near Suez, from rocks regarded as of Turonian age, in association with *Radiolites*.

Dr. Martin Duncan[1] next determined the species among Mr. Bauerman's fossils from Sinai, which are preserved in the Museum of the Geological Society of London. It was collected at Wady Nagh el Bader (= Wadi Budra), Duncan listing it as one of the commonest forms of the collection found in association with *Radiolites*, and belonging to an horizon equivalent to the Cenomanian of France.

[1] Duncan, P. M., "Note on the Echinodermata, etc., etc., from the Cretaceous Rocks of Sinai": Quart. Journ. Geol. Soc., vol. xxv (1869), pp. 44–46.

At a later date, M. Cotteau[1] recognized this Echinoid as occurring in the Turonian rocks of Algeria under the name of *Linthia oblonga*. On this occasion a change in the generic title was effected, without, however, any explanation being given by the author. This change was obviously necessary on grounds of priority, since Desor's *Linthia* of 1853 (*Actes Soc. Helvétique*, vol. xxxviii. p. 278) was synonymous with *Periaster*, founded by d'Orbigny in 1856.

During the year 1899 M. Fourtau[2] published a revision of the Fossil Echinoids of Egypt, containing a reference to *Linthia oblonga*. Besides quoting its occurrence in Algeria, he stated that the species was common in the neighbourhood of Angoulême, France, where it had been found at the base of the Angoumian deposits, and was consequently Upper Turonian. Moreover, M. Fourtau furnished a remark on the original locality given by d'Orbigny which is of interest to reproduce here: "Je ne connais point de Gebel Garèbe, près de Suez, seule une petite éminence au pied de l'Abou Daragué[3] porte le nom de Krouéba, c'est peut-être là que Lefébvre l'a récoltée à moins que ce ne soit dans les couches qui bordent le massif central granitique du Gebel Garib à 220 kilométres au sud de Suez sur les côtes de la mer Rouge, entre cette montagne et Gebel Zeit."

As this appears to embrace all the important references to *Linthia oblonga*, we will now attempt to solve the position of the original locality as given by d'Orbigny. According to his account M. Lefébvre collected the species at "Mont Garèbe, près Suez," a spot which appears to be unknown to M. Fourtau. An examination of the map, however, demonstrates that there is an eminence called Jebel Gharbi or Gharabi in a slightly south-easterly direction from Suez, which is in the neighbourhood of Wadi Budra, overlooking the Ramleh plain of Sinai. Although the specimens could not have been obtained from Jebel Gharbi itself, that being of granitic structure, it is quite possible that Lefébvre collected his material at Jebel Dhalal, which is in the vicinity, and where Mr. Thomas Barron knows the Cenomanian rocks to be present. Some of the best specimens of *Linthia oblonga* in the collection of the Geological Survey of Egypt have been obtained at Wadi Budra, as were Duncan's in previous years. This area of Sinai may therefore be regarded as the special habitat of the species, rather than those localities situated in the Eastern Desert of Egypt bordering the Gulf of Suez and the Red Sea, as suggested by M. Fourtau.

The Turonian age of *Linthia oblonga* as determined, at any rate, for the Sinai occurrence by d'Orbigny, is not now accepted, more especially as that author described *Hemiaster cubicus* and *Clavaster*

[1] Cotteau, Peron, & Gauthier: "Échinides Foss. Algérie," vol. ii (1879), fasc. 6, p. 75 (no figure given).

[2] Fourtau, R., "Révision des Échinides Fossiles de l'Égypte": Mém. Instit. Égyptien, vol. iii (1899), fasc. 8, pp. 631, 632.

[3] These place-names, which are difficult to find on ordinary maps of the district, will be found in an excellent topographical map accompanying M. Fourtau's paper, "Voyage dans la Partie Septentrionale du Désert Arabique": Bull. Soc. Khédiviale Géographie (Caire), 1900, ser. v, No. 9, p. 576.

cornutus also from Mont Garèbe, which are true Cenomanian species; and, moreover, we have it on the authority of Professor Rothpletz [1] that no Turonian rocks have been identified in the Sinai Peninsula, thus fully confirming the previous work of Duncan, who from an examination of the assemblage of fossils in this region was led to regard it as generally of a Cenomanian character. This horizon is also supported by the specimens collected by the Geological Survey of Egypt, which contain such fossils in association with *Linthia oblonga* as *Exogyra Africana* and *Exogyra Olisiponensis*.

In connection with *Hemiaster cubicus* it is interesting to note that according to modern writers that species is a frequent Cenomanian fossil of Sinai; yet Duncan never identified it in the Bauerman Collection, nor has the present writer been able to recognize it among the specimens collected by Mr. Barron. Professor A. Rothpletz [2] noted the occurrence of *H. cubicus* in the Cenomanian beds of Sinai during 1893; M. Fourtau [3] recognized it at Wadi Budra, etc., in beds of Lower Cenomanian age; Dr. Blanckenhorn [4] has also listed the species from similar regions of Sinai; whilst Dr. Hume [5] has met with it at Jebel Gunnah, in the eastern part of the peninsula, associated with *Pseudodiadema variolare* and *Heterodiadema libycum*. M. Fourtau's latest contribution on this subject calls attention to the eccentricity of the apex in *H. cubicus*, and the varieties of form that he has observed in the species, his examples coming from the neighbourhood of the Convent of St. Paul in the Arabian Desert, where the species is said to be characteristic of the base of the Cenomanian of Egypt. But it is not likely that any confusion could have occurred in the identification of these echinoids when the details of the test are considered. There is the great difference in form, as also in the pore structure of the anterior ambulacrum, whilst the presence in *Linthia oblonga* of a lateral as well as the peripetalous fasciole creates even a more striking separation. This lateral fasciole, which in the posterior region is situated beneath the anal orifice, is, unfortunately, not always definable, so much depending upon the state of preservation of the test; but it is traceable on Duncan's specimens in the Geological Society and also on some of those collected by Mr. Barron. There is a stratigraphical distinction also which deserves to be mentioned. According to M. Fourtau, *H. cubicus* belongs to the base of the Egyptian Cenomanian, whereas *L. oblonga*, from its association with *Exogyra*

[1] Rothpletz, A., "Stratigraphisches von der Sinaihalbinsel": Neues Jahrbuch, vol. i (1893), pp. 102–104.

[2] Rothpletz, A., "Stratigraphisches von der Sinaihalbinsel": Neues Jahrbuch, vol. i (1893), pp. 102–104.

[3] Fourtau, R., "La Côte Ouest du Sinai," Bull. Soc. Khédiviale Géographie (Le Caire), 1898, ser. v, No. 1, pp. 1–35; "Révision des Echinides Fossiles de l'Egypte," Mém. Instit. Egyptien, vol. iii (1899), fasc. 8, pp. 605–608, 628; "Note sur *Hemiaster cubicus*, Desor, et ses variations," Bull. Mus. Hist. Nat. [Paris], 1903, No. 3, pp. 177–180.

[4] Blanckenhorn, Max, "Neues zur Geologie und Palaeontologie Aegyptens": Zeitsch. Deutsch. Geol. Ges., vol. lii (1900), see chart facing p. 33.

[5] Hume, W. F., "Geology of Eastern Sinai": Geol. Mag., 1901, p. 203.

Africana and *E. olisiponensis*, is of Upper Cenomanian age. In fact, no Lower Cenomanian fossils have been recognized in the collection of the Geological Survey of Egypt, and, moreover, several of the species are found to pass up into the Turonian stage in other countries, as Dr. Choffat [1] has proved in connection with his researches in Portugal.

In conclusion, therefore, it is hoped that this note may claim the attention of the palæontologists of Egypt, and that *Linthia oblonga* may take its place in all future faunistic lists connected with the palæontology of Sinai.

I am indebted to my colleague, Dr. F. A. Bather, of the British Museum, for some useful suggestions during the preparation of this paper.

Linthia oblonga, Orbigny.

Periaster oblongus, Orbigny: "Pal. Française Terr. Crétacés Échinodermes," 1856, pl. 900, pp. 275, 276. P. M. Duncan, "Note on the Echinodermata, etc., from the Cretaceous Rocks of Sinai": Quart. Journ. Geol. Soc., vol. xxv (1869), pp. 44–46 (no figure or description).

Linthia oblonga, Cotteau, Peron, & Gauthier: "Echinides Foss. Algérie," vol. ii (1879), fasc. 6, p. 75 (not figured). Fourtau, "Révision Echinides Foss. Egypte": Mém. Instit. Egyptien, vol. iii (1889), fasc. 8, pp. 631, 632 (not figured).

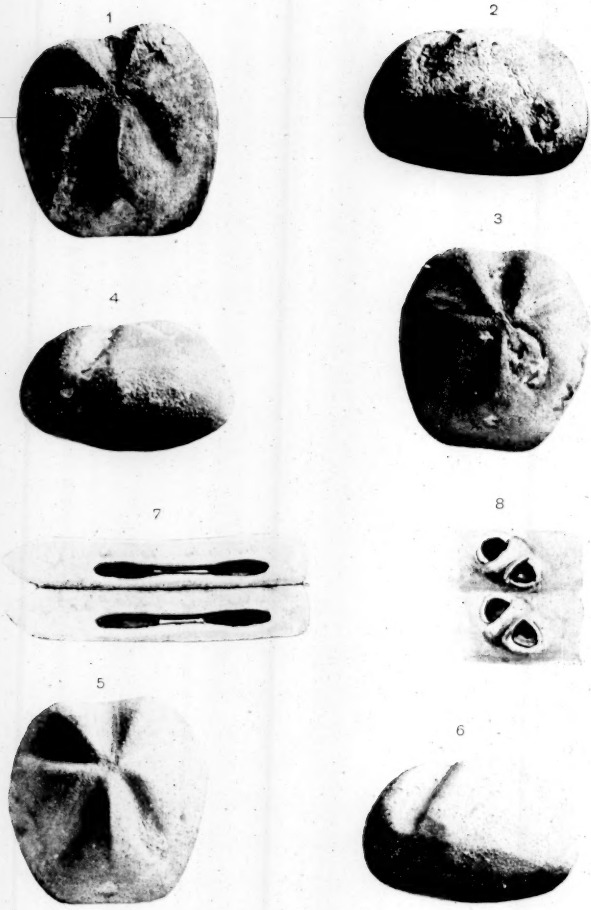
The test measurements of the three specimens selected for illustration are as follows:—

	(9004)	(9003)	($S\frac{3}{11}$)
Length	31	28	30 mm.
Width	27	21	27 mm.
Height	20	18	19 mm.

Nos. 9003 and 9004 represent Duncan's two principal specimens, and $S\frac{3}{11}$ is one of the Wadi Budra examples collected by Mr. T. Barron. All these are of the average size, although larger and even smaller ones are among the specimens of the Egyptian Survey Collection. The details of structure, so amply given in the original description, are well seen, although in the majority of the specimens it is not always possible to trace the lateral fasciole and its course beneath the anal aperture. This feature is, however, preserved in specimens represented by Figs. 4 ($= S\frac{3}{11}$) and 6 ($= 9003$). The structure of the pores, as observed in the anterior ambulacrum (Pl. XV, Fig. 8) and in the antero-lateral ambulacra (Pl. XV, Fig. 7), corresponds with that figured by d'Orbigny. The largest of Duncan's specimens (Fig. 1 = 9004) shows well-preserved apical characters, whilst the pores of the madreporite are observable on some eroded specimens obtained by Mr. Barron from the top of Jebel Safariah ($S\frac{3}{12}$).

The apex is anterior or nearly central in this species, although the abactinal views of the specimens selected for figuring present the idea of great eccentricity, a feature which has been brought about through slightly tilting the specimens so as to include the anal orifice. It is noticeable also that the right anterior corner of some of the specimens appears to be slightly higher than the left,

[1] Choffat, Paul: "Recueil de Monographies Stratigraphiques sur le Système Crétacique du Portugal," 1900.



Linthia oblonga (Orbigny).

Cretaceous (Cenomanian): Sinai.

a fact which is more than usually accentuated in the case of Duncan's largest specimen (see Pl. XV, Fig. 1), and although such a phenomenon may be due to some kind of deformity it is possible, as suggested by Dr. Bather, that it may have a wider and more structural explanation.

Localities.—Duncan's specimens collected by Mr. Bauerman were obtained at Wadi Nagh el Bader, and are preserved in the Museum of the Geological Society bearing the numbers 9003 and 9004. The specimens in the Geological Survey of Egypt Collection were obtained by Mr. Barron from the following places:—Wadi el Araba ($S\frac{3}{3}$, 4117); Wadi Budra ($S\frac{3}{1}\Gamma$, 3614), examples numerous and associated with *Exogyra Africana*; south end of Wadi el Araba ($S\frac{3}{1}\frac{3}{2}$, 3815), also found with the above-named shell; head of Wadi Esba ($S\frac{3}{2}\frac{3}{4}$, 3870), found with *Hemiaster Heberti* and *Exogyra olisiponensis*; Wadi Sifa ($S\frac{3}{2}\frac{3}{5}$, 4021); near top of Jebel Safariat ($S\frac{3}{4}\frac{3}{2}$, 4066), specimens numerous, but with eroded and worn tests, which are generally devoid of detailed characters, except that some of them show the madreporite.

EXPLANATION OF PLATE XV.

Linthia oblonga.

Cretaceous (Cenomanian): Sinai.

Fig. 1.—Abactinal view of Duncan's largest specimen (9004), slightly tilted to show the anal region.
,, 2.—Left side view of same specimen.
,, 3.—Abactinal view of Duncan's second specimen (9003), also slightly tilted to show anal region.
,, 4.—Left side view of same, exhibiting the peripetalous and lateral fascioles.
,, 5.—Abactinal view of one of Mr. Barron's specimens ($S\frac{3}{1}\Gamma$), tilted as before, for anal characters.
,, 6.—Left side view of same, showing obscure fascioles.
,, 7.—Pores of the antero-lateral ambulacra, enlarged.
,, 8.—Pores of the anterior ambulacrum enlarged, showing their oblique character and the dividing calcareous band.

Figs. 7 and 8 represent enlargements, whilst the remaining figures are of the natural size.

V. — On the Occurrence of an Opisthocœlian Dinosaur (*Algoasaurus Bauri*) in the Cretaceous Beds of South Africa.

By R. Broom, M.D., B.Sc., Corr. M.Z.S. Lond.

Last year, while the Port Elizabeth Brick and Tile Company were quarrying a clayey rock at Despatch, near Uitenhage, a number of bones were discovered in the rock. Though the discovery created some little interest, no one seems to have appreciated the scientific value of the find, and large numbers of the bones were made into bricks. A few fragments of vertebræ and ribs have been collected by the Port Elizabeth Museum, and recently an attempt has been made to rescue some more of the bones that still remain in the rock. So far a number of very imperfect fragments of vertebræ—cervical, dorsal, and caudal—a fairly good femur, an imperfect scapula, portions of many ribs, and an ungual

phalanx, have been discovered. The examination of these remains leaves no doubt that the skeleton is that of an Opisthocœlian Dinosaur of moderate size.

The scapular fragment represented the larger portion of the lower half of the bone of the right side. The posterior border is missing, but as the coracoid border is preserved, as well as a portion of the anterior, a very good idea can be obtained of the shape of the bone. As will be seen by the figure, it resembles considerably the scapula of *Brontosaurus*, though of very much smaller size. When complete, the greatest breadth from the prescapular border to the posterior part of the glenoid process would probably be about 200 mm.

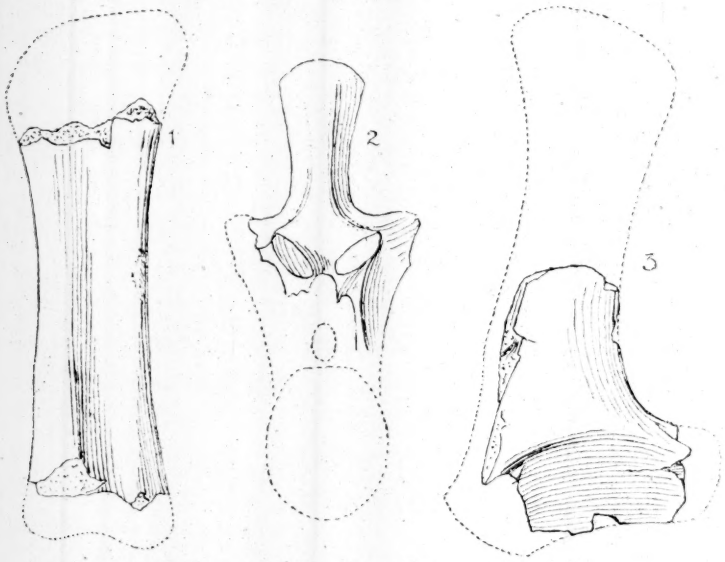


Fig. 1.—Left femur of *Algoasaurus Bauri*. × $\frac{1}{7}$.
Fig. 2.—Posterior dorsal vertebra of *Algoasaurus Bauri*. × $\frac{1}{7}$.
Fig. 3.—Right scapula of *Algoasaurus Bauri*. × $\frac{1}{7}$.

The femur has lost the upper and lower ends, but otherwise is perfect. Indications of both condyles can be seen at the lower end, so that a clear idea can be obtained as to how much is missing. A considerable portion of the upper end is lost, but it is probable that the upper end was shaped as in *Diplodocus*. The fourth trochanter for the femoro-caudal muscle is of much smaller size than in either *Brontosaurus*, *Diplodocus*, or *Morosaurus*, from which we may probably infer that the tail was less powerfully developed in the South African than in the American forms. When complete, the femur is estimated to have been 500 mm. in length, or about one-third the size of that of *Diplodocus*. Across the narrowest part the femur measures 120 mm.

Most of the vertebræ are too fragmentary to warrant description, but from the fragments it is manifest that the vertebræ have borne

considerable resemblance to those of *Diplodocus*. The few fragments of centra of the body vertebræ show the peculiar excavations seen in the centra of the American types. The best preserved vertebra is the one figured. It is probably one of the posterior dorsals. The spine shows a complicated arrangement of laminæ very similar to that of the spines of the posterior dorsals of *Diplodocus*, but owing to the condition of the specimen it is difficult to represent this in the figure. The height of the vertebra, when complete, would probably be about 450 mm., or less than half the size of the last dorsal of *Diplodocus*.

I propose to name this new reptile *Algoasaurus Bauri*, after the late George Baur, whose early death removed from the ranks of investigators one who could ill be spared.

VI.—Note on a Pillow-lava apparently forming a continuous horizon from Mullion Island to Gorran Haven in Cornwall.

By G. T. Prior, M.A., F.G.S.

THE basalt of Mullion Island, with the intercalated radiolarian chert, is well known from the descriptions of Teall and Howard Fox.[1] It is a fine-grained minutely vesicular basalt, consisting mainly of radiating felspar laths and interstitial pale purplish-brown augite, and occurring in peculiar pillowy or bale-like masses. Owing to this curious structure and its intercalation with the chert the basalt is considered to be a submarine lava.

A well-marked horizon of radiolarian chert similar to that of Mullion Island has been traced by Mr. Howard Fox[2] from that island across the Lizard peninsula to Porthallow, and thence to the other side of Falmouth Bay to Pendower and Gorran Haven.

Lately, in the company of Mr. Upfield Green, I have made a collection of igneous and other rocks from the north of the Lizard, south of Helford river, and from the neighbourhood of Gorran and Caerhayes on the other side of Falmouth Bay. Many of the volcanic rocks are almost precisely similar, both in pillow structure and in microscopical characters, to the Mullion Island basalt. The following is a list of the localities, besides Mullion Island, at which this particular kind of basalt was found:—

Tregidden.—The basalt occurs here in two quarries on opposite sides of the stream; in one of them to the east the pillow structure of the rock is well marked. In microscopical characters the basalt is precisely similar to that of Mullion Island. It is finely vesicular, and shows minute interlacing felspar laths with much interstitial pale purplish-brown augite, and little or no iron-oxides. It varies in coarseness of grain, and in parts is much altered, so that the augite is unrecognizable. To the west of Tregidden, nearer to Mullion Island, precisely similar basalt was met with at Trethewy

[1] Quart. Journ. Geol. Soc., vol. xlix (1893), p. 211.
[2] Trans. Roy. Geol. Soc. Cornwall, xii (1), 1896, p. 39.

and near the Methodist Chapel at St. Martin, but at Trethewy the specimen obtained, which was coarsely vesicular, was found loose on a heap of pebbles, and at St. Martin there is some doubt whether the rock was actually *in situ*.

Still further west, at Lower Garras 'gravel-pit,' was found a crushed and brecciated radiolarian chert, exactly similar in microscopic characters to that of Mullion Island.

Roskruge Lane and Higher Boden.—In the lane leading from Roskruge to Higher Boden, on the right-hand side, occurs an andesitic basalt showing large porphyritic felspars. Under the microscope these phenocrysts are seen to occur in a groundmass consisting of a mesh of felspar laths with interstitial dark grains of what is probably altered augite. Some yards distant, on the same side of the road, to the east of a small stream, was found a basalt consisting of felspar laths and interstitial brown augite, precisely similar to the Mullion Island rock, but of slightly coarser grain. Similar basalt occurs in a quarry farther up the lane on the left-hand side near Higher Boden. The association of a basalt like that of Mullion Island with a markedly porphyritic variety is repeated on the other side of Falmouth Bay in a quarry near Tubbs Mill (see below).

Porthallow.—The rock at Porthallow is similar to some of the varieties of basalt found at the quarries near Tubbs Mill on the other side of Falmouth Bay (see below). It shows a trachytic mesh of felspar laths with dark interstitial grains of altered augite, and passes on the margin into a spherulitic glass.

Nare Head (east side of Falmouth Bay).—On the top of Nare Head was found a basalt consisting, like the Mullion Island rock, of felspar laths and interstitial purplish-brown augite, but containing also a few porphyritic felspars. It was associated with a variety of much coarser grain, approaching a dolerite in character. At Pennare Wallas, north of Nare Head, occurred a radiolarian chert similar to that of Mullion Island.

Quarries near Tubbs Mill (north of St. Michael Caerhayes).—In a quarry east of Trevennen, on the right-hand side of the road leading to Tubbs Mill, occurs a basalt showing fairly well-marked pillow structure. The rock is like the Mullion Island basalt, and consists of felspar laths and altered interstitial augite. As in the case of the Porthallow rock, it passes on the surface of the pillows into a glass showing well-marked spherulitic structure. In the large quarry just north of Tubbs Mill is seen the close association of a finely vesicular basalt, consisting of felspar laths and pale purplish-brown augite, precisely similar to the Mullion Island rock, with a variety showing a similar groundmass, but with numerous fairly large porphyritic felspars. A similar association of a basalt like the Mullion rock with a porphyritic variety occurs also in an overgrown disused quarry amongst osiers to the east of Trevennen on the left-hand side of the road leading to Tubbs Mill.

Great Perhaver Beach.—A mass of basalt showing well-marked pillow structure and microscopic characters, similar to those of the

Mullion Island basalt, forms the projecting headland at the south end of the Great Perhaver Beach, north of Gorran Haven.[1]

These localities mark out almost precisely the same horizon as the radiolarian cherts of Mr. Howard Fox. The curve followed by this pillow-lava is also fairly parallel to that of the well-known quartzite of the Meneage and Gorran districts, to the slate containing limestone lenticles with Upper Silurian fossils, and to that of the conglomerate placed by Mr. Upfield Green at the base of the Gedinnian. Fragments of an altered basalt very similiar to the Mullion Island rock were found in this conglomerate along Gillan Creek, at Flushing and Lestowder Beaches.

NOTICES OF MEMOIRS, ETC.

I.—British Association for the Advancement of Science. Cambridge Meeting, 1904.

Address to the Geological Section by Aubrey Strahan, M.A., F.R.S., F.G.S., President of the Section.

IT is forty-two years since the British Association last met in Cambridge, and we may turn with no little interest to the record of what was taking place at a date when the science of geology was still in its infancy, and in a University where its promise of development was first recognised. Dr. John Woodward, the founder of the Woodwardian Chair, had been dead 176 years, but his bequest to the University had not long begun to bear fruit, for the determination to house suitably the collection of fossils and to provide for the reading of a systematic course of lectures was not arrived at until 1818. In that year Adam Sedgwick, on his appointment to the Woodwardian Chair, began a series of investigations into the geology of this country, which made one of the most memorable epochs in the history of British geology. At the Cambridge meeting of 1862 he had therefore held the Professorship for forty-four years, a period sufficient to spread his reputation throughout the civilised world as one of the pioneers of geological science.

Towards the close of his life Sedgwick gave expression to the objects which he had had in view when he accepted a Professorship in a science to which he had not hitherto specially devoted his attention. "There were three prominent hopes," he writes, "which possessed my heart in the earliest days of my Professorship. First, that I might be enabled to bring together a collection worthy of the University, and illustrative of all the departments of the science it was my duty to study and to teach. Secondly, that a geological

[1] Igneous rocks occur at the top of Greeb Head and at Little Perhaver Beach, but they are of more acid trachytic type than the Mullion Island rock, and show large porphyritic crystals of oligoclase in a fine-grained felspathic base with little or no development of ferromagnesian minerals. Fragments of somewhat similar trachytic rocks, but containing shreds of opacite suggestive of altered soda-pyroxenes or amphiboles, were found in a crushed breccia of grit and slate on the north-east of Porthluney Cove.

museum might be built by the University, amply capable of containing its future collections; and lastly, that I might bring together a class of students who would listen to my teaching, support me by their sympathy, and help me by the labour of their hands."

We, visiting the scene of his labours more than thirty years after he wrote these words, witness the realisation of Sedgwick's hopes. The collection is not only worthy of the University, but has become one of the finest in the kingdom. It is housed in this magnificent memorial to the name of Sedgwick, on the completion of which I offer for myself, and I trust I may do so on behalf of this Section also, hearty congratulations to the Woodwardian Professor and his staff. Finally, I may remind you that at this moment the Directorship of the Geological Survey and the Presidential Chair of the Geological Society are held by Cambridge men; that the sister University has not disdained to borrow from the same source; and lastly, that it is upon Cambridge chiefly that we have learned to depend for recruiting the ranks of the Geological Survey, as proofs that Cambridge has maintained her place among the foremost of the British schools of geology.

Though he had taken a leading part at former meetings of the Association, Sedgwick's advanced age in 1862 necessitated rest, and this Section was deprived to a great extent of the charm of his presence. It benefited, however, in the fact that the Presidential Chair was occupied by one of his most distinguished pupils. Jukes was one of those men the extent of whose knowledge is not readily fathomed. It has been my experience, and probably that of many others in this room, to find that some conclusion, formed after prolonged labour and perhaps fondly imagined to be new, has been arrived at years before by one of the old geologists. Such will be the experience of the man who follows Jukes' footsteps. Turning to his Address given to this Section in 1862, we find much of what is now written about earth-movement and earth-sculpture forestalled by him, with this difference, however, that whereas the custom is growing of using a phraseology which may sometimes be useful, but is generally far from euphonious, and not always intelligible, he states his arguments in plain, forcible English.

It may raise a smile to find that Jukes thought it necessary in 1862 to combat the view that deep and narrow valleys had originated as fissures in the crust of the earth, and that the Straits of Dover must have been formed in this way, because the strata correspond on its two sides. But we shall do well to remember that the smile will be at the public opinion of that day, and not at Jukes himself. In no branch of geology have our views changed more than in the recognition of the potency of the agents of denudation. In 1862 it was necessary to present preliminary arguments and to draw inferences which in 1904 may be taken as granted.

The evidences of the prodigious movements to which strata have been subjected, and of the extent to which denudation has ensued, cannot fail to strike the most superficial observer. Both mountain

and plain present in varying degree proof that sheets of sedimentary material originally horizontal are now folded and fractured. But after a momentary interest aroused by some example more striking than usual, glimpsed, it may be, from a train-window, the subject is probably dismissed with an impression that such phenomena are due to cataclysms of a past geological age and have little concern for the present inhabitants of the globe. These stupendous disturbances, it might be argued, can only have taken place under conditions different from those which prevail now. We are familiar with mountain-ranges in which their effects are conspicuous ; we have carried railways over or through them and have been troubled by no cataclysmic movements of the strata. Apparently the rocks have been fixed in their plicated condition, and are liable to no further disturbance. Parts of the world, it is true, are subject to earthquakes accompanied by fissuring and slight displacement of the crust, but not even in earthquake regions can we point to an example of such thrusting and folding of the strata being actually in progress as have taken place in the past. Nor, again, can volcanic activity be appealed to, for some of the most highly disturbed regions are devoid of igneous rocks. Volcanic eruptions are more probably the effect than the cause of the disturbances of the crust. Nowhere in the world therefore, it will be said, can we see strata undergoing such violent treatment as they have experienced in the past. How, then, can we dispute the inference that the forces by which the folding was produced have ceased to operate ?

Before accepting a conclusion which would amount to admitting that the globe is moribund and that the forces by which land has been differentiated from sea have ceased to act, we shall do well to look more closely into the history of the earth-movements to which any particular region has been subjected. The investigation is one which calls for the most intimate knowledge of the geological structure, and, as time will admit of my dealing with a small area only, I shall confine my observations to England and Wales, selecting such facts as have been established beyond dispute.

At the outset of the investigation we find reason to conclude that the movements, so far as any one region is concerned, have been intermittent. Evidence of this fact is furnished wherever any considerable part of the geological column is laid open to view. Sheets of sediment, aggregating perhaps thousands of feet in thickness, have been laid down in conformable sequence, all bearing evidence of having been deposited in shallow seas. The inference is inevitable that that period of sedimentation was a period of uninterrupted subsidence. But sooner or later every such period came to an end. Compression and upheaval took the place of subsidence, and the strata lately deposited were plicated and brought within the reach of denudation. Illustrations of the recurrence of these movements abound, and I need dwell no further upon them than to remark that movements of subsidence and upheaval may be seen to have alternated wherever opportunity is afforded for observation.

On extending our observations we are led to infer that the movements of the crust were developed regionally, not universally. The areas of subsidence, for example, evidenced by the marine formations had their limits, though those limits did not coincide with the shores of existing seas, nor has reason been found to believe that the proportion of land to sea has varied greatly in past times. The limits of the area affected by any one movement of upheaval are more difficult to determine, but the effects were manifested in the crumpling up of comparatively narrow belts of country, and are easy of recognition.

Further than this, we ascertain that the movements of one region were not necessarily contemporaneous with those of adjoining regions. The forces operating upon the crust of the earth came into activity in different places at different times, and, while some Continental tracts have been but little disturbed from early geological times, there are parts of the globe which have been the scene, so to speak, of almost ceaseless strife. Among the latter we may include the British Isles.

These are commonplaces of geology, and I mention them merely to emphasise the fact that the geological structure of these islands is the result of movement superimposed upon movement. Obviously, therefore, in order to gain a comprehensive view of the operations which were in progress in any one region during any one epoch, we have to find some means of distinguishing the movements of that epoch and of eliminating all which preceded or followed it. This, briefly, is the problem which has engaged the attention of geologists for many years past, and upon which I propose to touch.

The determination of the age of a disturbance is seldom easy, and among the older Palæozoic rocks is often impossible; but at the close of the Carboniferous period, during the great Continental epoch which led to and followed upon the deposition of the Coal-measures, there came into action a set of movements of elevation and compression, which generally can be distinguished both from those which preceded them and from those which have been superimposed upon them. The distinction depends upon the determination of the age of the rocks affected by the movements. For example, a movement by which the latest Carboniferous rocks have been tilted from their original horizontal position is obviously post-Carboniferous. On the other hand, if Permian rocks lie undisturbed upon those tilted Carboniferous rocks, it is equally obvious that the movement was pre-Permian. Now it happens that earth-movements of the date alluded to were particularly active in the British Isles, and played an important part in shaping the platform on which the Permian and later rocks were laid down. Though they have been more completely explored than others in the working of coal, their further investigation is of the greatest economic importance. I have attempted, therefore, briefly to sketch out the principal lines along which earth-movements of that age came into operation in England, premising, however, that by Permian I mean the Magnesian Limestone series, and not the "Permian of Salopian type," which is now

known to be partly of Triassic but principally of Carboniferous age. In the course of the investigation we shall find reason to conclude that several at least of the movements followed old axes of disturbance, lines of weakness dating from an early period in the history of the habitable globe; and, again, that some of the latest disturbances of which we have cognisance were but renewals of movement along the same general lines.

One of the most clearly proved examples of pre-Permian faulting in the Carboniferous rocks occurs in the Whitehaven Coalfield. The fault forms the south-eastern limit of the Coal-measures, and has been precisely located for a distance of six miles. In its course towards the south-west it passes under five outliers of Permian rocks, and finally is lost to sight under the Permian and Trias of St. Bees. The dislocation in the Carboniferous rocks amounts to about 400 yards, but the Permian rocks have not been even cracked; though broken and displaced by numerous faults of later date, they pass undisturbed over this great dislocation, the movement along it obviously having ceased before they were deposited. This fault forms part of the upheaval which brought the older rocks of Cumberland and Westmoreland to the surface, and in that sense it may be said to form the north-western frontier of the Lake District.

On the north-eastern side also of the Lake District the Permian rocks rest upon uptilted Carboniferous strata, but the axis of upheaval runs in a north-north-westerly direction and defines what we may regard as the north-eastern frontier. Along this frontier much movement has taken place in post-Permian times, but the unconformable relations of the Permian and Carboniferous rocks enable us to distinguish that part of the tilting which intervened between the two periods. On the south-eastern frontier also the Carboniferous rocks had been upheaved and denuded before the Permian sandstones were laid down. A huge fault, along which Carboniferous rocks have been jammed from the east in a multitude of plications against Silurian, runs from Kirkby Stephen by Dent to Kirkby Lonsdale, and thence trends south-eastwards by Settle. It is highly probable, though it has not been proved, that this fault is of pre-Permian age. That the Pendle axis which upheaves the Lower Carboniferous rocks between Settle and Burnley is pre-Permian is placed beyond doubt by the fact that an outlier of Permian rests upon the denuded crest of the anticline near Clitheroe.

The south-western frontier is defined by a still more marked unconformable overlap by the Permian strata, which here pass over the edges of the lowest members of the Carboniferous series and come to rest upon the Lake District rocks.

We have thus defined the sides of an oblong tract which was upheaved in the period we are considering. The older rocks forming the northern part of that tract had already had imposed upon them a dominant north-easterly strike by a pre-Carboniferous movement of great energy. As a result also of that and other movements they had been subjected to vast denudation, not only

in the Lake District, but throughout the north-west of England generally. But while it is doubtful whether any of the physical features then produced have survived, it seems to be beyond dispute that it was in consequence of the pre-Permian movements that the older rocks of the Lake District were freed from their Carboniferous covering, and that to this extent the district may be said to have been blocked out in pre-Permian times. The detailed sculpturing resulted from later movements, with which we are not now concerned.

During this same period there rose into relief that part of the Pennine axis which runs between Lancashire and Yorkshire. The doming up of the Lower Carboniferous rocks and the wildness of the moorlands which characterise their outcrops have impressed all who have had occasion to cross from the one populous coalfield to the other, and have gained the name of the 'backbone of England' for this anticlinal axis. Whether, however, it can be regarded as one axis or as the result of several movements is doubtful, but not material for our present purpose. Regarded as a geological structure it is not continuous with that part of the Pennine axis which runs along the north-eastern frontier of the Lake District.

Passing westwards from the Pennine axis, we cross the deep and broad Triassic basin of Cheshire, which may be regarded as the complement of the dome of elevation of Derbyshire. To the west of this, again, we reach a part of North Wales which was more or less shaped out by the earth-movements which came into action between the Carboniferous and Permian periods. Two leading faults traverse the district. The one runs in a north-north-westerly direction across Denbighshire and introduces that little bit of "Cheshire in Wales" known as the Vale of Clwyd. Though there has been some later movement along this fault, it was in the main pre-Triassic, which statement, in view of the perfect conformity between the Permian and Trias, amounts to saying that it was pre-Permian. The other passes across Wales in a north-easterly direction along the Dee Valley at Bala, and reaches the Triassic basin between Chester and Wrexham. The date of this fault has not been worked out in detail, but the fact that it is associated with a pre-Triassic anticline, where it reaches the Triassic margin, proves that it is in part at least of pre-Triassic age. In Anglesey also there has been strong post-Caboniferous folding in the same north-east to south-west direction.

It is to be noticed, further, that the Carboniferous rocks maintain their characters to their margins on the flanks of the Clwydian Hills and other ranges of Silurian rocks in North Wales. Both along the coast, and even in a little outlier preserved near Corwen by an accident of faulting, they show a persistence of type and of detail in sequence which could hardly have been maintained had the Silurian uplands existed in Carboniferous times. The inference that the uplands of Denbighshire and Flintshire are the result of post-Carboniferous upheaval is strengthened by the fact that the Carboniferous rocks reposing on their flanks are tilted at an angle which would carry them over their tops. This part of North Wales,

therefore, presents a history corresponding in its main events with that of the Lake District. It had undergone elevation and denudation in pre-Carboniferous times on a scale so vast that rocks showing slaty cleavage and other indications of deep-seated metamorphism had been laid bare. But in both cases it was in consequence of the post-Carboniferous movements that the leading physical features as they exist to-day began to take shape.

In both these regions pre-Carboniferous movements had been extremely active. For example, an axis of compression and upheaval ranges from north-east to south-west, involving the Lake District, the Isle of Man, and Anglesey. It belongs to the Caledonian system of disturbances which is developed on a large scale further north, and which sufficed here to cause slaty cleavage and presumably the extrusion of the Shap granite. I mention this pre-Carboniferous axis to point out that it offers an explanation of the direction taken by the post-Carboniferous disturbances of Whitehaven, Pendle, Anglesey, and possibly Bala. With the exception of the last-named they lie well within the region affected, and alone among the post-Carboniferous axes take that particular direction.

The Pennine axis ends as a particular feature in South Derbyshire and North Staffordshire on the margin of a deep channel filled with Triassic marl, which extends westwards from Nottingham into Shropshire. In this part of England there springs into existence a remarkable series of disturbances tending to radiate southwards. The westernmost of these is the great fault which forms the western boundary of the North Staffordshire Coalfield. Recent work by Mr. W. Gibson has shown that the vertical displacement of the Coal-measures amounts to no less than 900 yards, but that it is far less, though recognisable, in the Trias, proving that the disturbance was in the main pre-Triassic. The fault ranges from Macclesfield in a south-south-westerly direction, is lost to view under the Trias near Market Drayton, but is recognisable further on in the great dislocation which passes along the western side of the Wrekin, and thence through Central Shropshire by Church Stretton to Presteign in Radnorshire, and thence into Brecknock.

The second is the Apedale Fault of the North Staffordshire Coalfield. In working the coal this disturbance has been found to possess the structure of a broken monocline, a fold with fracture such as may be regarded as an early stage in the formation of an overthrust from the east. It runs through the coalfield in a direction slightly east of south, and then passing under the Trias of Stafford ranges for Wolverhampton and Stourbridge. This fault is mainly pre-Triassic, but what Mr. Gibson believes to be a continuation of it, following the same direction as far south as Hanbury, certainly effects a great movement in the Trias.

The third disturbance runs on the east of the Forest of Wyre Coalfield in a direction a little west of south. Here, as I learn from Mr. T. C. Cantrill, the thrust from the east is obvious, for Old Red Sandstone has been pushed from that direction against and even over Coal-measures, while the strata have been forced up into

a vertical position for some miles. In South Staffordshire all the Carboniferous rocks, including the "Salopian Permian," are involved in this and the previously mentioned movement, proving that both disturbances were of post-Carboniferous date.

Traced southwards this disturbed belt leads to Abberley, and there connects itself with the well-known Malvernian axis. The broken belt known by that name runs north and south, and may be followed almost continuously from Worcestershire to Bristol. It presents evidence of having been a line of weakness through a large part of the world's history, as shown by Professor Groom, and of having yielded repeatedly to earth-stresses; but there is seldom difficulty in distinguishing the movements which were effected during the period under consideration. For example, near and south of Abberley the Coal-measures are clearly involved in a thrust from the east, which was sufficiently energetic to turn over a great belt of Old Red Sandstone and other rocks beyond verticality for some miles. Further south, again, among repeated proofs of the ridging up of the old axis in several pre-Carboniferous periods, we find evidence of post-Carboniferous elevation along the same general line. Throughout this same region there has been also post-Triassic dislocation, which, however, is on a comparatively small scale. That the Carboniferous rocks were greatly disturbed before the Trias was laid down is proved by the great unconformity between the two formations.

The Malvernian axis continues southward by Newent, but perhaps with diminishing intensity. On its west side a broad syncline rolls in the tract of Carboniferous rocks which underlies the Forest of Dean. The syncline trends north and south, and is shown to be of pre-Triassic age by the fact that the Triassic strata on the banks of the Severn do not share in the synclinal structure. Here we must leave the Malvernian axis for the present.

The fourth disturbance ranges along the Lickey Hills, which, diminutive as they are, tell a story of great geological significance. They range in a south-south-easterly direction, and in the fact that they are formed of extremely ancient rocks furnish evidence of immense upheaval. From the relations of these ancient formations to one another we may gather also that the upheaval was due to a recurrence of movement along the same axis at more than one geological date, but at the same time we find no difficulty in distinguishing that part of the movement which took place between Carboniferous and Triassic times, for the Coal-measures are tilted up on end along the flanks of the axis, while the Trias passes horizontally over all the tilted rocks. A clue to the southward extension of the axis under the Secondary rocks is furnished by some faulting as far as Redditch, here also there having been a renewal of movement on a small scale in post-Triassic times.

The fifth disturbance runs through Warwickshire, and includes the low ridge of ancient rocks which ranges through Atherstone and Nuneaton in a south-easterly direction. About fifteen miles to the north-east Archæan rocks form the parallel ridge or series

of ridges of Charnwood Forest, while the intervening space is overspread by Trias, resting partly on Carboniferous and partly on older strata. The structure of the Carboniferous and older strata is dominated by what is known as the Charnian movement, which includes disturbances of several ages ranging in a south-easterly direction. That part of the movement which was post-Carboniferous is identifiable by the fact that Coal-measures are tilted on either side of the ridges of old rocks. They once overspread both ridges, but were removed by denudation as a consequence of upheaval before the Trias was deposited. It has been found also in working the coal, as I am informed by Mr. Strangways, that there are large faults having the south-eastward or Charnian direction which shift the Coal-measures, but do not break through the overlying Trias. The evidence, therefore, of a great Charnian movement having taken place during the period under consideration is conclusive. The disturbance ranges as a whole in the direction of Northampton, where, in fact, borings have reached the Charnwood rocks at no great depth.

The five great disturbances which I have briefly indicated tend to converge northwards, but their exact connection with the Pennine axis is not known. What may be only a part of that axis trends for Charnwood through a tract of Lower Carboniferous rocks exposed at Melbourne, between the Yorkshire and Leicestershire Coalfields, but the Triassic channel I have already mentioned intervenes, and the structure of the rocks underlying the red marl is unknown. The channel itself appears to be of Triassic age, for not only is the depth of marl in it suggestive of its having been a strait in the Triassic waters, but its northern margin has been found by Mr. Gibson to coincide with, and perhaps to have been determined by, faults known to be mainly of pre-Triassic age. One of these, with a downthrow of 400 yards to the south, runs from Trentham through Longton, and south of Cheadle, while another ranges from near Nottingham to the north of Derby.

We come now to the south-west of England, where we find striking proofs of a still more energetic movement than any yet mentioned having intervened between the Carboniferous and Triassic periods. The central part of the Armorican axis, as it has been called, after the ancient name of Brittany, trends nearly east and west, and keeps to the south of our South Coast; but we have opportunities in Devon and Cornwall of seeing some of the stupendous effects produced along its northern side. A belt of country measuring some 130 miles in width has been completely buckled up. Slaty cleavage was superimposed upon the intricate folds into which the strata were being thrown, while after or towards the close of these phenomena granite was extruded at several points along the belt of disturbance, a little north, however, of the line along which the oldest rocks were brought up to the surface. In Devon the Culm-measures are fully involved in the movement, but on the other hand the Permian strata, while containing fragments of the cleaved and metamorphosed rocks, are

themselves wholly free from such structures. The age of the folding, cleavage, and extrusion of the granite is thus definitely fixed as having been subsequent to the deposition of the Culm-measures, but previous to that of the Permian rocks.

But we may fix the age still more closely. A broad syncline of Carboniferous rocks traverses Mid-Devon, and is succeeded northwards by an anticline and by an extrusion of granite at Lundy Island, the age of which, however, has not yet been definitely ascertained. Still further north in a series of folds and overthrusts which traverse the southern margin of South Wales we can recognise the last effects of the great Devonshire movement at a distance of not less than 130 miles from the central axis, the ground-swell, so to speak, subsiding as it receded from the distant storm-area. Here the higher Carboniferous rocks are involved, and thus prove that this part at least of the Armorican disturbance was of post-Carboniferous age.

In Dorset, Somerset, and Gloucestershire the Palæozoic rocks pass eastwards under Secondary formations, and are seen no more in the south of England. That the disturbance continues, however, is inferred from the fact that it has been traced across a large part of the continent of Europe in the one direction and across the south of Ireland in the other. The determination of its position therefore, and especially of the effects of its intersection with the Midland disturbances, is of the greatest importance in view of the possible occurrence of concealed coalfields under the Secondary rocks. One such intersection is open to observation.

The Malvern and Devonshire disturbances intersect in Somerset. On investigating their behaviour as they approach we may notice in the first place that the subsidiary axes which form the northernmost part of the Devonshire disturbance in South Wales die away one after the other towards the east. Thus an east and west disturbance at Llanelly runs a few miles and disappears. The more important Pontypridd anticline, which traverses the centre of the coalfield, fades away near Caerphilly, while the coalfield itself terminates a little further east, its place on the same line of latitude being taken by the Usk anticline, which trends southwards and south-westwards. So far it might be inferred that the east and west folds die away on approaching the north and south Malvernian axis. But the Cardiff anticline, which lies south of and was more energetic than those mentioned, crosses the Bristol Channel and, emerging on the other side in a complicated region near Clevedon and Portishead, passes to the north of Bristol and holds its course right across the coalfield at Mangotsfield. The coalfield, however, lies in what is part of the Malvernian disturbance, for it occupies a syncline running north and south along the west side of the main axis of the upheaval. Though the interruption is local and the strata recover their north and south strike to the south of it, yet the east and west axis obviously holds its course right through the Malvernian structure.

Still further south, in the direction in which the east and west movements gradually increase in energy, a series of sharp folds is

well displayed in the coast of South Wales and in an island in the Bristol Channel, ranging for that part of the east and west disturbance which is known as the Mendip axis. This name has been applied to a series of short anticlines which are arranged *en échelon* along a line ranging east-south-east, but each of which runs east and west. Among them we may distinguish the Blackdown anticline, the Priddy anticline, the Penhill anticline, north of Wells, and the Downhead anticline, north of Shepton Mallet. With one exception they all die out eastwards after a course of two to ten miles, but the Downhead anticline holds its course into the Malvernian disturbance, the two engaging in a prodigious *mêlée* south of Radstock. From that much shattered region the Downhead anticline emerges, but the Malvernian axis is seen no more, and, so far as can be judged under the blanket of Secondary rocks, comes to an end.

Mention has been made of the fact that many of the subsidiary east and west folds die away on approaching the Malvernian axis. In a general way we may attribute their disappearance to the influence of the north and south movement, for it is commonly to be observed in these great belts of disturbance that they are composed of a number of parallel anticlines or elongated domes of upheaval, constantly replacing one another; it is a common feature also that these subsidiary folds replace one another not exactly in the direction in which they point, but that they lie *en échelon* along a line slightly oblique to it. The behaviour of the South Wales and Mendip folds is in accordance with these observations, and may be taken to indicate that the effects of the east and west disturbance reached further north in South Wales than they did in Somerset, or, in other words, that they failed to penetrate as far into the region where north and south movements were in progress as in the region where there were no movements in that direction.

The fact that the east and west folds keep their course across the north and south wherever the two actually meet comes out prominently, and supports the inference that they dominate the structure of the Palæozoic rocks which lie hidden beneath the Secondary rocks of the south and south-east of England. Somewhere under this blanket of later formations the east and west axis presumably intersects the other disturbances which traverse the Midlands. To ascertain where and how the intersections takes place will be going far towards locating any concealed coalfields which may exist; but the knowledge can be obtained only by boring, and the number of such explorations as yet made is wholly insufficient. The majority have been made in search of water, and have been stopped as soon as a supply was secured. Near Northampton the older rocks were reached at a small depth on what is believed to be the underground continuation of the Charnian axis, and a boring at Bletchley traversed what is thought to have been a great boulder of Charnian rock, suggesting that the axis is not far off; but with these exceptions the counties of Oxford, Buckingham, Bedford, Huntingdon, Cambridge, and Norfolk are unknown ground. Yet under these counties the axes must run

if they keep their course. Where exposed at the surface each post-Carboniferous syncline between two axes contains a coalfield. It remains to future exploration to ascertain whether similar conditions hold good under the Oolitic and Cretaceous areas of Central England.

In speaking of the north and south disturbances I have in more than one case stated that the post-Carboniferous movement was but a renewal of activity along an old line of disturbance. The fact is proved by the unconformities visible among the pre-Carboniferous rocks, and it is important for the reason that the geography of this part of the globe at the commencement of the Carboniferous period had been determined by these movements. It has long been known, for example, that the parts of the counties of Stafford, Warwick, and Leicester traversed by the axes of upheaval were not submerged till late in the Carboniferous period. On the other hand, some of the area lying immediately west of the Malvernian axis was submerged at an earlier date, as is shown by the existence of Carboniferous Limestone at Cleobury Mortimer and, in greater development, in the Forest of Dean. The borings near Northampton also proved the presence of Carboniferous Limestone, a fact which is in favour of the occurrence of concealed coalfields, in so far as it indicates that the whole Carboniferous series may have once existed there. It is remarkable that none of the borings in the south and east of England have touched Carboniferous Limestone, all having passed into older or newer rocks. The existence of that formation is neither proved nor disproved.

The determination of the age of these disturbances and a discussion of the pre-Carboniferous geography may seem at first sight to be only of scientific interest, but that problems of great economic importance are involved has been shown recently. It has long been known that the principal coal-seam of South Staffordshire deteriorates westwards as it approaches the pre-Carboniferous ridge evidenced in the neighbourhood of Wyre Forest. There seemed, however, to be no theoretical reasons why it should not keep its characters on either side of the fault which forms the western boundary of the South Staffordshire Coalfield, inasmuch as that fault came into existence after the deposition of the Coal-measures. A shaft recently sunk has proved the correctness of the inference. The seam has been found to be well developed to the west of the fault, and a considerable addition has been made to our productive coalfields.

So much has been written about the range of the Devonshire disturbance under the south of England that I shall add no more than a brief comment on some of the evidence on which reliance has been placed. We have seen that there has been some post-Triassic movement along old lines of disturbance in North Wales and the Midlands and along the Malvern axis. It is suggestive, therefore, to find that in the region which we believe to be underlain by the east and west disturbance east and west folding forms the dominant structure of the Secondary and Tertiary rocks.

The anticlines of the Vales of Pewsey and Wardour, the London syncline, the Wealden anticline, the Hampshire syncline, and the

anticline of the Isles of Wight and Purbeck, not only lie in the range of the axis, but show an increasing intensity southwards, towards what we may suppose to have been the most active part of that axis. A similar structure prevails in the Oolitic rocks also. They too had been thrown into east and west folds before the Cretaceous period, and this earlier set of movements also grew in intensity towards the south. It would seem, then, at first sight that the structure of the later rocks gives an easy clue to the structure of the older rocks buried beneath them. This is by no means the case. That the movements manifested in the Oolitic and Cretaceous rocks followed the same general line as the older movement admits of little doubt, but that the later structures correspond in detail with the earlier is improbable.

A brief examination of the region where the Carboniferous rocks disappear under the Secondary formations will give the grounds for this statement. There we find that the Trias passes over the complicated flexures of the Mendip axis in undulations so gentle as to prove that those flexures had been completed before it was deposited. Nor, again, do the members of the Oolitic group of the rocks cropping out in succession further east show any such folds as those visible in the Carboniferous, and it is not till we have passed over a considerable tract of Secondary rocks in which there are no signs of east and west folding that we reach the anticlines of the Vales of Pewsey and Wardour. Nor can we then fit these folds in the Cretaceous formation on to any visible axes in the Carboniferous rocks. Under these circumstances it would be unjust to suppose that such synclines and anticlines as those of the London and Hampshire basins, or of the Weald, coincide with previously formed synclines and anticlines in the older rocks. They give a clue to the position of the old axis, but not necessarily to the details of its structure. Yet it is upon the determination of the position of the older anticlines and synclines, and of their intersection with the north and south disturbances, that we must depend for locating concealed coalfields. So far but little has been done in the forty-eight years since the question was first mooted by Godwin-Austen. The existence of a coalfield in Kent has been proved, and what appears to be a prolongation of a disturbance from the Pas de Calais along the south-western side of it. The other borings which have reached the Palæozoic floor round London and at Harwich have thrown but little light on the details of its structure. By far the greater part of the ground remains yet to be explored.

In this brief review of the earth-movements of one period, as manifested in one small part of the globe, we have found reason to conclude that they were the result of compression and upheaval; that the crust yielded to the compression by overthrusting and buckling along certain belts; that these belts in the north of England and the Midlands ran for the most part north and south, diverging, however, to the south-west and to the south-east, while in the south of England they took an east and west direction and

concentrated themselves along a belt of country which presents the phenomena of crushing on a stupendous scale. We have touched in two cases the flanks of a mountain-range, the Caledonian, which was built and ruined before the Carboniferous period; the Armorican, which was built after that period, and which, though it has stirred so recently as the late Tertiary period, and so energetically as to initiate the physical features and river-system of the south of England, yet expended the greater part of its energy before the Permian period. Lastly, we have found evidence, in the majority of cases, that the disturbances were but renewals of movement along lines of weakness long before established, and that in several cases there has been further renewal along the same lines during successive periods later than the one we have considered. With such a history before us, and with the knowledge that mountain-ranges have been built in other parts of the world by the upheaval of strata of almost recent date, we have more cause to wonder that the internal forces have left this quarter of the globe alone for so long, than reason to believe that they have ceased to exist. Changes of level, however, have taken place in comparatively recent times, and are now in progress. Though almost imperceptibly slow, they serve to remind us that a giant lies sleeping under our feet who has stretched his limbs in the past, and will stretch them again in the future. Nor in view of the fact that the structures I have described have only been revealed by the denudation of vast masses of strata does it seem unreasonable to suppose that they are deep-seated phenomena. The slow changes of level may be the outward manifestation of more complicated movements being in progress at a depth.

It is interesting to speculate on what appearance the globe would have presented had it not been enveloped in an atmosphere and covered for the most part with water. Owing to those circumstances it possesses the power of healing old wounds and burying old scars. In their absence we may suppose that the belts of crushing and buckling would have given rise to ridges growing in size at every renewal of movement, for they would have been neither levelled by denudation nor smoothed over by sedimentation. This globe, we may suppose, would have appeared to the inhabitants of another planet as being encompassed in a network, and we are prompted to ask whether our astronomers can distinguish in any other planet markings that may be attributable to this cause. I must remind you, however, how much more remains to be done than I have been able to touch upon to-day. The map (exhibited) represents one episode only in a long series of events, and a series of such maps would be required to illustrate the first appearance of lines of weakness in the earth's crust, the subsequent renewals of movement along those lines, and the formation of new lines in successive geological periods. With the case thus set out we shall be justified in appealing to the physicists for an explanation of the restlessness of this globe.

II.—Short Notices.

1. South African Geology.—Dr. F. H. Hatch extends our knowledge of the geology of the Transvaal by describing in Trans. Geol. Soc. South Africa (vii, 1904) the Marico district. This is stated to be a great syncline formed by the Pretoria beds, the Dolomite and Black Reef Formations, and the underlying Ventersdorp beds. Dr. Hatch describes the interesting igneous complex to which reference has been made by Molengraaff under the name of the "Plutonic Series of the Bush Veld." In this complex the great development of pyroxenite with associated peridotites would appear to constitute an outer ultra-basic zone. For, as one travels eastwards, one traverses successively zones of a more and more acid type, until rocks are reached in which quartz plays the predominant *rôle*. A rough map attached to the paper explains this succession.

Dr. Corstorphine, in dealing with the Central South African Coalfield (Trans. Geol. Soc. South Africa, vi), considers that the coal of Vereeniging and that of the Orange River Colony, as well as that of the Eastern Transvaal and the neighbouring portion of Natal, is of Ecca Age. Molengraaff (ibid.) concludes that the remarkable tectonics of the Vredefort mountain-land have been caused by the intrusion of a huge granite boss, the Vredefort granite, which phenomenon took place after the deposition of the rocks of the Cape System (Black Reef series, Dolomite series, and Pretoria, or Gatsrand, series), and before the deposition of the strata of the Karroo System; and in the discussion which followed, Hatch said he agreed, and that Molengraaff was also probably correct with regard to the overtilting of the Witwatersrand beds.

J. P. Johnson has described (ibid.) some implement-bearing gravels in the neighbourhood of Johannesburg. These show facies of true Eoliths, Palæoliths, and Neoliths, as compared with European examples, and the author comes to the conclusion that the Bezuidenhout Valley drift must be much newer than the hill-drift of Rordekop, and that the close of the Neogene era in South Africa saw much the same evolution in the culture of its stone-age as did that of the Thames basin and the rest of Britain and Western Europe, and that such progress must have taken an approximately equal length of time.

J. Kuntz (ibid.) gives an interesting example of the pseudomorphosis of quartz pebbles into calcite. T. N. Leslie, in reviewing the fossil flora of Vereeniging, carefully points out the many errors that have occurred in recording various plants from these beds, and gives Seward's final list of plants as showing the Permo-Carboniferous age of these plants as compared with those of India and South America.

The Annual Reports for 1901 and 1902 of the Geological Commission of the Cape of Good Hope provide much matter of special interest. Messrs. Rogers and Schwarz report on a journey from Swellendam to Mount Bay, on a general survey of the rocks in the southern part of the Transkei and Pondoland, including

a description of the Cretaceous rock of Eastern Pondoland, and on a geological survey of the Kentani division. The shells and bones in the Cretaceous appear to be rolled and rounded in the lowest beds. The bones include those of Chelonia, and a lower jaw resembling that of *Mosasaurus*, while sharks' teeth also occur. Further reports by the same authors deal with the Matatiele division, with an account of the petrography of the volcanic rocks, and on the divisions of Beaufort West, Prince Albert, and Sutherland. The authors propose a slightly different classification of the Karroo System, in that they separate the Dwyka series from the Ecca.

2. Ceylon.—The Report of the Director of the Mineralogical Survey of Ceylon Administration Reports, 1903, pt. iv (Miscellaneous), has just reached us. The Mineralogical Survey was established in the latter part of 1902 for three years, the objects being an examination of the occurrence of economic minerals in the island with a view to their further development and the preparation of a report descriptive of the mineral resources, as well as the arrangement of the geological collections in the Museum and the accumulation of further specimens, a duplicate series being reserved for exhibition at the Imperial Institute. A separate guide to the geological collections is to be ultimately prepared.

The staff consists of a Director, A. K. Coomáraswámy, an assistant director, James Parsons, an office peon, two overseers, a 'collector' (*sic*), and eight coolies. The staff is sanguine enough to suggest that 1,000 square miles can be superficially surveyed in the course of a year. Perhaps we under-estimate the capacity of the peon.

The greater part of Ceylon consists of ancient crystalline rocks, granulites, or, in a wide sense, gneisses, which belong to the Charnockite series. Mica seems to be the most important economic mineral in the area reported upon, and includes muscovite, biotite, and phlogopite, of which the latter is of chief commercial importance. Graphite, the most important of all the mineral resources of the island, is chiefly distributed in areas outside the range of this report, but sketches of several mines are given. Working, however, depends on the price of the graphite, which is at present low. Iron is the only metal treated of. The precious stones mentioned are Corundum, Moonstone and Garnet, and the other mineral mentioned is Pitchblende (Uraninite), but a footnote states that the materials from Bambarbotuwa and Gampola are probably not Uraninite but a new mineral, whose detailed composition is not yet certain. Mr. Coomáraswámy does not believe in the reported discoveries of Cinnabar, he thinks Sindurankanda was 'salted,' and that there is no geological probability of there being ore of mercury at Kotte.

The arrangement of the Museum goes on slowly but surely, and the Director asks for a special grant to enable him to secure and exhibit a representative collection of gems.

3. *Euceratherium.*—This is a singular quaternary ungulate found by W. J. Sinclair and E. L. Furlong in the caves of the Shasta country, California. Its affinities are not clear. It may be placed in the Ovinæ, but cannot be regarded as intimately related to any existing North American member of that group. The cranium is larger than in the big-horn sheep, while the horn-cores are smaller, are situated much further behind the orbits, and differ greatly in form and curvature. Although there is a resemblance to *Ovibos* in dental structure, the horn-cores are of an entirely different type. A relationship with the cattle is excluded by fundamental differences in dental structure. It is separated from the goats by the presence of a lachrymal pit. This character serves to distinguish *Euceratherium* from *Haplocerus*, from which it differs also in greater size, in the shape and position of the horn-cores, and in the exclusion of the parietal from the cranial roof. The description and plates appear in Bull. Geol. Univ. California Publications, iii, 1904.

4. Geology under the Planetesimal Hypothesis of Earth-Origin.—In the Bull. Geol. Soc. Amer. (xv, 1904) H. L. Fairchild discusses the bearings on several problems in geology of the new hypothesis of earth-origin recently formulated by T. C. Chamberlin. This hypothesis will shortly be printed in full in a new text-book by T. C. Chamberlin and R. D. Salisbury. Its comparison with the nebular theory is thus given by Fairchild: "The old hypothesis assumes the existence of a mass of incandescent vapour, with or without a nucleus, which by condensation and rotation was differentiated into successive rings, the latter being eventually gathered into the planets while still retaining intense heat. From this postulate there necessarily follows the conception of a cooling earth, and hypogeic geology has been founded on the idea of crustal solidification on a molten globe. The new hypothesis holds that the disseminated planet-forming matter had lost its heat while yet existing in the loose form, as rings or wisps of the parent nebula, and that the globular planets were formed by the slow accretion or infalling of cold discrete bodies or particles ('planetesimals').

"The old hypothesis assumes an originally hot globe with shrinking on account of cooling. The new regards the globe as originally and always cold at the surface, and the interior heat as the product of gravitational condensation. The old view requires continuous cooling of the globe, while the new allows the conception of increasing internal heat. The old hypothesis makes the earth of largest size at birth and of constantly diminishing volume. The new regards the earth as beginning with a small nucleus and slowly growing by surface accretion, but with large reduction of volume by compression during and subsequent to the accretionary process. The old hypothesis involves the recognition of a primal heated atmosphere and ocean consisting of the more volatile substances of the earth's mass. The new derives the present fluid envelopes from the earth's interior by a slow process of expulsion due to pressure and heat."

Having thus distinguished the new theory from the old, Fairchild

discusses on the new basis the following points:—Origin of the atmosphere and ocean; earliest sedimentary rocks; volcanic phenomena; source of the hydrocarbons; genesis of metalliferous deposits; origin of gypsum and salt; climates; glaciation; diastrophic movements; irregularities of the earth's figure; and life on the earth.

5. The Frank Landslip.—The Department of the Interior of the Dominion of Canada, in their Annual Report for 1903, has issued a report on the disastrous landslide at Frank, by Messrs. R. G. McConnell and R. W. Brock. Turtle Mountain, the eastern face of which gave way on 29th April, 1903, consists of Devonian Limestones resting on Cretaceous shales and sandstones. The Devonian beds dip to the west at an average angle of 50°. The fall occurred about 4.10 a.m., and consisted of a mass of rock half a mile square, and 400 to 500 feet thick. The mass broke across the bedding planes almost at right angles, and therefore the slide falls under Balzer's heading of 'Bergstürtz,' of which it is a typical example. The mass appears to have been shattered into fragments during its descent, and the material seems to have travelled by a succession of great leaps, or ricochets, rather than by a true slide. The bulk of the fallen mass is calculated at nearly 36,000,000 cubic yards, equal in weight to some 80,000,000 tons. The primary cause of the breaking away of the mass from Turtle Mountain is to be found in the structure and condition of the mountain itself. It was ripe for a slide. The steep slopes, the shattered and fractured nature of the rocks, particularly of the basal beds of the limestone series, overlying a thrust-fault, coupled with unusually heavy precipitation, are causes which in themselves are quite sufficient to have produced the slide, and, unaided, the loosened masses would sooner or later have fallen. The report points out the probability of further slides in the same area, and advises the inhabitants of Frank to move up the valley.

REVIEWS.

I. — On some Additional Fossils from the Vancouver Cretaceous, with a Revised List of the Species therefrom. By J. F. Whiteaves, LL.D., F.G.S., etc. Geological Survey of Canada, part v, pp. 309–416, pls. 40–51. (Ottawa, August, 1903.)

THIS is the concluding part of the first volume of illustrated reports upon the Cretaceous fossils from the Queen Charlotte and Vancouver Islands, the first part of which appeared in 1876. It deals more particularly with the fossils which have been obtained from Vancouver and the adjacent islands since 1879. The rocks containing these fossils were named the Nanaimo group by the late Dr. Dawson, and, as now understood, this group appears to be the equivalent, not only of the Chico group of California, but also

of the Pierre-Fox Hills or Montana formation of Manitoba, the North-west Territories, and the Upper Missouri country; also, in a general way, of the Upper Chalk of England and the Senonian of the Continent. Dr. Kossmat correlates it more particularly with the upper part of the Senonian. The fossils of this group are very similar to those of the higher beds of the Upper Cretaceous in the Island of Saghalien, in Japan, and Southern India. On the other hand, they very distinctly differ from those in the somewhat older Cretaceous rocks of the Queen Charlotte Islands, and only a few species are common to both formations.

With the exception of a single species of *Unio* and a few doubtful gasteropods, the Nanaimo fauna is exclusively marine. The following are the more salient features of the fauna as enumerated by the author:

Fishes.—These are very few, and only comprise vertebræ of teleosts, the centrum of a vertebra of a Selachian which, in an earlier part, had been described as a new species of *Discina*, and teeth of *Lamna appendiculata*. The fish remains had been submitted to Dr. A. Smith Woodward, F.R.S.

Crustacea.—The Decapoda are fairly numerous, and nine species have lately been described by Dr. Henry Woodward, F.R.S. They belong to the following genera: *Plagiolophus*, *Palæocorystes*, *Callianassa*, *Hoploparia*, *Enoploclytia*, *Eryma*, *Meyeria*?, *Glyphæa*, and *Linuparus*.

Ammonitidæ.—The genus *Pachydiscus* is largely developed, and no fewer than eight species are enumerated or described. They have been studied by Dr. F. Kossmat of Vienna, and directly compared with allied species from Southern India and Europe. No species of *Pachydiscus* has yet been discovered in the Cretaceous of the Queen Charlotte Islands. *Baculites* likewise does not occur in these Islands, though one species is very common in the Nanaimo group.

Gasteropoda.—A small smooth species of *Cypræa* is present; there are also three large species probably belonging to *Mesostoma*, Deshayes; a *Solariella* hardly distinguishable from *S. radiatula*, Forbes, from the Cretaceous rocks of Saghalien and Southern India; and a large limpet-like shell, which is probably only a variety of *Helcion giganteus*, from the Cretaceous of Saghalien.

Pelecypoda.—A considerable reduction has been made in the number of species of *Inoceramus*, as both the *I. undulatoplicatus*, Roemer, and *I. mytilopsis*, Conrad, are now considered to be synonyms of *I. digitatus*, Sowerby, which occurs in the Cretaceous of Texas, Nebraska, and Saghalien. Also a species of *Unio* has been found, apparently distinct from *U. Hubbardi*, Gabb, from the Queen Charlotte Island Cretaceous.

The new forms are illustrated in the accompanying plates, and a list of the fossils of the Nanaimo group is appended; there is also an index to the generic and specific names occuring in the volume.

II.—"Ueber die Morphologie und Morphogenie der Rugosa." On the Morphology and the Morphogeny of the Rugosa. By N. Jakowlew. From the "Verhandlungen der Russisch-Kaiserlichen [Mineralogischen Gesellschaft," Bd. xli, Lief 2. St. Petersburg, 1904.]

IN a paper under the above title N. Jakowlew deals with the structural peculiarities of the Rugose Corals, seeking to explain these peculiarities in the light of possible relationships between the Rugosa and the Hexacorals.

The most remarkable characteristic of the Rugosa compared with the Hexacorals is their bilateral symmetry, of which the chief expressions are the bent corallum, the presence of a main septum ('hauptseptum'), and of a fossula ('septalgrube').

As many as four fossulæ have been claimed as occurring in some forms of Rugosa, but it is shown that the depressions at the alar septa ('seitensepten') are not to be distinguished by any morphological difference from other interseptal loculi, so that no fossula occurs except in the plane of symmetry of the coral. Nor can any instance be found of two fossulæ occurring in the plane of symmetry. And when one occurs, the septum situated in it has always been found to be the main septum. Therefore the presence of a fossula always indicates the presence of the main septum.

Some would define the main septum as that primary septum which occurs on the convex side of the coral. Nicholson is quoted as an author who does so. It is shown, however, that the peculiarities which distinguish the main septum are the behaviour of the other septa towards it, as shown by their outcrops on the surface of the corallum after the epitheca has been removed. From this aspect the outcrops of the secondaries are seen to be pinnately arranged with regard to that of the main septum, and parallel to that of the counter septum ('begenseptum'); also those between the alar septum and the main septum (i.e. those in the main quadrants) are parallel to the former, while those between the former and the counter septum (i.e. those in the counter quadrants) meet the alar septum at an angle. Again, the outcrops of the secondary septa in the main quadrants meet the plane of the mouth opening (or, what is the same thing, the lines of growth) at an oblique angle, while those in the counter quadrants meet the lines of growth at right angles.

Thus defined, the main septum is found to occur, often in the same genus, now on the concave and now on the convex side of the corallum. That is to say, the two chief expressions of bilateral symmetry in the Rugosa (the presence of the fossula having been shown to be bound up with that of the main septum), namely the bending of the coral—what might be called 'external bilateral symmetry'—and the presence of the main septum—what might be called 'internal bilateral symmetry'—occur independently of each other. The question naturally arises, which appeared first? Whether the bending caused the bilateral symmetry, or whether "the bending . . . . arises from a tendency in the coral towards bilateral symmetry."

If the bilateral symmetry is the result of the bending, we must imagine a young form, having a hereditary tendency towards radial symmetry, varying from its ancestral type by growing in a curved manner instead of straight. This curved growth became fixed in its descendants, the curved form having been selected owing to some advantage it gained over its straight fellows, possibly by presenting a mouth more or less perpendicular to a horizontal current bearing the food supply. The curvature of the corallum, caused perhaps by unequal growth, perhaps by the falling over of the coral as its bulk increased, or by some unknown agent, induced bilateral symmetry in the soft parts by causing them to gravitate towards the lower side of the mouth opening. The skeleton thenceforward secreted was, therefore, bilaterally symmetrical, because it could only take the shape of the soft parts by which it was formed. This is in the main H. M. Bernard's view, who says that the formation of the fossula would be a natural outcome of this gravitation of the soft parts.

On the other hand, Duerden has suggested that the bilateral symmetry arose from the abortion of two of the six original primary septa. The ancestors of the Rugosa (yet to be discovered!) were radially symmetrical Hexacorals. Variations in these, whereby two primary septa failed to grow above a certain size, were seized upon by natural selection, for the possession of some unknown advantage, and became fixed. The two defective septa were those primaries adjacent to the counter septum. Moreover, in the loculi between these and the counter septum no secondaries appeared. By subsequent growth the secondary septa grew as large as the two defective primary septa, and so the appearance of four primary septa arose.

Of course the abortion of two septa may have been caused by the bending of the corallum, in which case the two hypotheses would only differ in that in the former a radially symmetrical Tetracoral was the original ancestor, while in the latter a radially symmetrical Hexacoral. And the settlement of this point might have some bearing on the question whether the Hexacorals are the descendants of the Rugosa, or whether both had a common ancestor, and, if the latter, whether this ancestor was a Hexacoral or a Tetracoral.

Whatever view of the origin of the bilateral symmetry is taken, the fact remains that the position of the main septum with regard to the bending of the coral has no connection with the origin of that bending. It is only suggested in explanation that the comparative rarity of corals having the main septum on the concave side may be due to the fact that in these the lower part of the mouth opening might be brought too near the sea-bottom to be clear of the injurious sediment rapidly accumulating thereon. And, further, uncertainty is expressed as to the value of the position of the main septum as a systematic character; whether to regard it as of specific or of varietal importance.

A new explanation of the origin of the fossula is suggested. There would be a natural tendency for the soft parts to sink in the

spaces between the main septum and the adjacent septa, where the new septa are inserted when, by the growth of the coral, the space became larger than the other interseptal loculi, just before the insertion of a new septum.

Such, we think, are the chief facts brought forward and the chief questions touched upon in this paper, which, while containing new and interesting observations, and raising important questions, does not do much towards solving these questions, and is lacking in arrangement; so much so that it is exceedingly hard to follow any thread of argument running through the whole; and beyond giving a clear definition of the main septum, and showing that it occurs indifferently on the convex and concave side of the corallum, the paper does little but put forward suggestions bearing on the origin of the peculiarities of the Rugosa. W. D. L.

III.—The Geology of the Oolitic and Cretaceous Rocks south of Scarborough. By C. Fox-Strangways, F.G.S. Ed. II. Memoirs of the Geological Survey England and Wales. pp. i–iv, 1–119. With 11 plates and numerous woodcuts. (London, 1904. Price 4*s.* 6*d.*)

THIS memoir is designed to illustrate and explain sheets 54 and 55 (New Series) of the Geological Survey. It contains a great amount of most useful and interesting information, not only concerning the Secondary Rocks, from the Lower Oolites to the Upper Cretaceous, of the district covered by these sheets, but also deals with various superficial deposits. Further, there are certain remarks concerning the physical and geographical features, but these are somewhat disappointing reading: the author gives the impression that he lacks a firm grip of the principles of these subjects, which have been so ably handled in various modern text-books.

The chief value of the memoir lies in its geological and palæontological information. Looking at it from the foreigner's point of view, we may regret that the author does not indicate his zones more fully throughout his various sections, so that the stranger may see at a glance with what rocks at home he may compare these Yorkshire strata. But a great help to such a stranger are the excellent plates reproduced from photographs, showing characteristic sections. Only here one must be allowed a regret—that the tracing-paper plans covering the plates were not more carefully lettered. A fine feature is spoiled by a small detail; for these plans are not always legible. They lack care in their preparation.

In the matter of illustration the palæontological portion of this memoir has not been liberally treated. The indifferent woodcuts are not creditable to the author's work, for in many cases they fail to give recognizable pictures; and, what is more serious, they are not illustrations made from local fossils. They are just stock woodcuts, and it is plain that they have had a past. They should not be allowed a future.

The palæontological nomenclature claims to be brought up to date. In the phytological portion this it must be admitted has been done—Seward's Catalogue has very properly been followed; but in the zoological part it can hardly be granted. We might suggest that, as authors of such memoirs cannot possibly be specialists in all branches of nomenclature, they would be well advised to follow the latest text-book. They might reasonably plead "Theirs not to reason why," and simply trust the specialists who had contributed to the text-book: on these specialists would fall praise or blame as the case might be. Such a text-book we have now in the Eastman translation of Zittel; but, tested by that, the nomenclature in this memoir is certainly not up to date. For instance, generic names which have been discarded from the text-book on account of prior use, meet us throughout the pages of this memoir, while names which have been in use for many years, and are to be found even in the old Zittel of twenty years ago, are lacking. Only the Ammonite names seem to be up to the modern standard, tested by Eastman, but there is one failure here, viz., the figure given as *Ammonites humphriesianus*, on p. 13, is not that species, for it was separated by Oppel some fifty years ago, and taken by him as the type of his *A. bayleanus*. We are credibly informed, and Oppel himself says the same, that the species does not occupy the same zone as *A. humphriesianus*. It is, therefore, very doubtful if this figure represents a fossil which occurs in Yorkshire at all. It clearly proves the necessity of illustrating each memoir with special figures taken from actual local fossils.

When the reader has been safeguarded in reference to such matters as these to which we call attention, then he will find the memoir an extremely interesting and useful guide to a very important district. A. B. L.

IV.—Palæozoic Arachnida. By Professor Dr. Anton Fritsch. 4to, with pp. 88, 15 plates, and 99 figures in the text. (Prag, Selbstuverlag, Fr. Rivnác, & Buchdruckerei Dr. Ed. Grégr a Syn, 1904. See also Sitzungsber. k. Akad. Wiss. Wien., cxii.)

THIS work forms one of a series of Memoirs to the preparation of which Dr. Fritsch has devoted so many years of his long and laborious life in illustration of the fauna of the Coal-formation of Bohemia.

In the present monograph, which is published under the auspices of the Imperial Academy of Vienna, the author has extended the field of his researches, and examines and describes and figures the fossil Arachnida in the Museums of London, Paris, Dresden, Breslau, and Vienna, visited by him in 1903, in order to embrace the whole of the known forms of palæozoic Arachnida from all countries.

The 15 quarto plates and the greater number of the 99 illustrations in the text are drawn by the author's own hand.

Thirty-nine[1] genera and 67 species of Arachnida are here recorded

[1] One genus and species, *Adelocaris peruvianus*, should be cancelled: see p. 473, No. 28.—H. W.

and more or less fully described by the author. Of these, 37 Carboniferous and Permo-Carboniferous species are from Bohemia, 6 Carboniferous are from Silesia, 1 in the Dresden Museum, 1 from the Coal-measures of Bavaria, 2 from France, 1 from Belgium, 1 from Scotland, 5 from England, 1 from South Wales, 1 from Arkansas, and 7 from Illinois, U. S., North America (and 1 very doubtful from Peru); these are Coal-measure forms; whilst of air-breathing Silurian scorpions Gotland has yielded 1, Scotland 2, and North America 1.

The following list may serve to give an idea of the fossil genera and species known at the present time:—

Order ARANEA.

Suborder ARTHRARACHNÆ. Haase.

Family ARTHROLYCOSIDÆ (Harger), Fr.

LOWER COAL-MEASURES (Steinkohlen Formation).

1.—Genus Arthrolycosa, Harger.
antiqua, Harger: Coal-m., Illinois.
carbonaria, Kusta, sp.: ,, Rakonitz, Bohemia.
fortis, Fritsch: ,, ,, ,,
Lorenzi, Kusta, sp.: ,, ,, ,,
palaranea, Fritsch: ,, Radnitz, ,,
Beecheri, Fritsch: ,, Rakonitz, ,,

2.—Protolycosa, Fritsch.
anthracophyla, Röm.: Coal-m., Silesia.

3.—Geralycosa, Kusta.
Fritschii, Kusta: Coal-m., Rakonitz, Bohemia.

4.—Rakovnicia, Kusta.
antiqua, Kusta: Coal-m., Rakonitz, Bohemia.

5.—Eotarbis, Kusta.
litoralis, Kusta: Coal-m., Rakonitz, Bohemia.

Suborder PLEURARANEÆ, Fr.

PERMO-CARBONIFEROUS SERIES.

Family HEMIPHRYNIDÆ, Fr.

6.—Hemiphrynus, Fritsch.
longipes, Fr.: Gas-coal, Nyran, Bohemia.
Hofmanni, Fr.: ,, ,, ,,

Family PROMYGALIDÆ, Fr.

7.—Promygale, Fritsch.
bohemica, Fr.: Gas-coal, Nyran, Bohemia.
rotundata, Fr.: ,, ,, ,,
elegans, Fr.: ,, ,, ,,

8.—Perneria, Fritsch.
salticoides, Fr.: ,, ,, ,,

9.—Eopholcus, Fritsch.
pedatus, Fr.: Coal-m., Nyran, Bohemia.

10.—Pleurolycosa, Fritsch.
prolifera, Fr.: Gas-coal, Bohemia.

11.—Brachylcosa, Fritsch.
carcinoides, Fr.: Gas-coal, Bohemia.

12.—Pyritaranea, Fritsch.
tubifera, Fr.: Gas-coal, Nyran, Bohemia.

Order OPILIONES, Sund.

Suborder OPILIONIDÆ, Veri.

COAL-MEASURES.

13.—Nemastomoides, Thevenin.
elaveris, Thev.: Coal-m., Commentry, France.

14.—Dinopilio, Fritsch.
gigas, Fr.: Coal-m., Rakonitz, Bohemia.

COAL-MEASURES.

Suborder MERIDOGASTRA, Thorel.

Family POLIOCHERIDÆ, Scudder.

15.—POLIOCHERA, Scudder.
punctulata, Scudder: Coal-m., Illinois, U.S.A.

Family ARCHITARBIDÆ, Karsch.

16.—GERAPHRYNUS, Scudder.
carbonarius, Scudder: Coal-m., Illinois, U.S.A.
elongatus, Scudder, sp.: Coal-m., Illinois, U.S.A.
17.—ARCHITARBUS, Scudder.
rotundatus, Scudder: Coal-m., Illinois, U.S.A.
suboralis, H. Woodward: Coal-m., Lancashire.

Family, ANTHRACOMARTIDÆ.

18.—ANTHRACOMARTUS, Karsch.
Krejcii, Kusta: Coal-m., Rakonitz, Bohemia.
minor, Kusta, ,, ,, ,,
affinis, Kusta, ,, ,, ,,
socius, Kusta, ,, ,, ,,
volkelianus, Karsch: Coal-m., Silesia.
granulatus, Fr.: Coal-m. (in Dresden Museum).
trilobitus, Scudder: Coal-m., Arkansas.
palatinus, v. Ammon: Coal-m., Palatinate, Bavaria.
19.—BRACHYPYGE, H. Woodward.
celtica, Pocock: Coal-m., Cardiff, South Wales.
carbonis, H. Woodw.: Coal-m., Mons., Belgium.
20.—ANTHRACOSIRO, Pocock.
Woodwardi, Pocock: Coal-m., Coseley, Dudley.
Fritschi, Pocock: ,, ,, ,,
21.—EOTROGULUS, Thevenin.
Fayoli, Thev.: Coal-m., Commentry, France.
22.—VRATISLAVIA, Fritsch.
silesiaca, F. Roemer: Coal-m., Silesia.

Family EOPHRYNIDÆ, Karsch.

23.—EOPHRYNUS, H. Woodward.
prestwicii, Buckland, sp.: Coal-m., Coalbrook Dale, Shropshire.
(*Stenotrogulus*) *Salmii*, Stur.: Coal-m., Silesia.
24.—CYCLOTROGULUS, Fritsch.
Sturii, Haase, sp.: Coal-m., Mährisch Ostrau, Silesia.
25.—KREISCHERIA, Geinitz.
Wiedei, Gein.: Coal-m., Zwickau, Bohemia.
26.—HEMIKREISCHERIA, Fritsch.
Thevenini, Fr.: Coal-m., Westphalia.
27.—PETROVICIA, Fritsch.
proditoria, Fr.: Coal-m., Petrovic, Rakonitz, Bohemia.
28.—ADELOCARIS *peruvianus*, Packard [said not to be an Arachnide, but a Macruran-Crustacean]: loc. incog. (Jurassic?), Peru.

Order PEDIPALPI, Latr.

Tribe UROPYGI, Thor.

Family THELYPHONIDÆ, Auctorum.

29.—PROTHELYPHONUS, Fr.
bohemicus, Kusta, sp.: Coal-m., Rakonitz, Bohemia.
[GERALINURA (syn. of *Prothelyphonus*?)]
Scudderi, Kusta: Coal-m., Rakonitz, Bohemia.
noctua, Kusta: ,, ,, ,,
crassa, Kusta: ,, ,, ,,
(*Prothelyphonus*) *Cordai*, Fr.: Coal-m., Radnitz, ,,

Order SCORPIONES.

Suborder APOXYPODES, Th. & L.

Family PALÆOPHONIDÆ, Th. & L.

SILURIAN.

30.—PALÆOPHONUS, Th. & L.
nuncius, Th. & L.: Upper Silurian, Gotland.
Hunteri, Pocock: Upper Silurian, Lesmahagow.
loudonensis, Laurie: Upper Silurian, Pentland Hills.
(PROSCORPIUS) *Osborni*, Whitfield: Upp. Silur., N. America.

Family ANTHRACOSCORPII, Th. & L.

CARBONIFEROUS FORMATION.

31.—CYCLOPTHALMUS, Corda.
senior, Corda: Coal-m., Bohemia.
32.—MICROLABIS, Corda.
Sternbergii, Corda: Coal-m., Bohemia.
33.—ISOBUTHUS.
kralupensis, Th. & L., sp.: Coal-m., Kralup, Bohemia.
34.—EOBUTHUS, Fr.
Rakornicensis, Fr.: Coal-m., Rakonitz, Bohemia.
35.—ANTHRASCORPIO, Kusta.
juvenis, Kusta: Coal-m., Rakonitz, Bohemia.
36.—EOSCORPIUS, Meek & Worthen. [U.S.A.
carbonarius, M. & W.: Coal-m., Mazon Creek, Illinois,
anglicus, H. Woodw.: Coal-m., near Dudley.
37.—MAZONIA, Meek & Worthen. [U.S.A.
Woodiana, M. & W.: Coal-m., Mazon Creek, Illinois,
38.—GLYPTOSCORPIUS, Peach.
caledonicus, Peach, sp.: Carb. R., Eskdale, Scotland.

PERMO-CARB.

39.—FEISTMANTELIA, Fritsch.
ornata, Fr.: Permo-Carboniferous, Lebach, Bohemia.
(ISOBUTHUS?) *Nyranensis*, Fr.: Permo-Carboniferous, Nyran, Bohemia.

There is not the least reason to assume that the Arachnida were better represented in the Carboniferous and the Permo-Carboniferous of Bohemia than in any other Coal-areas of Europe and America; it merely shows that more careful attention has been directed towards the collecting of the fossil fauna of these beds there than elsewhere, and that Dr. Fritsch has been more energetic in describing them than the palæontologists of some other Coal-regions. Much splendid work has, however, been done with the Insect fauna of North America by S. H. Scudder and by the late lamented Charles Brongniart in that of Commentry, France, as well as by the workers in other countries, and we may look forward with confidence to great accessions to our knowledge in this field of research as soon as the splendid material obtainable becomes better known.

Of the Bohemian specimens of special interest may be recorded the remains of *Arthrolycosa carbonaria*, Kusta, from Rakonitz, a genus also met with and described by Harger from the Coal-measures of Illinois, U.S.A., of which good material for four other species have likewise been obtained in Bohemia. It is extremely interesting to record the discovery of a specimen of this genus, *A. palaranea*, Fr., still attached to a leaf of *Cordaites* as in life.

Protolycosa anthracophyla, described by F. Roemer in 1866 from the Coal-measures of Silesia, is also reproduced with care.

Another spider, *Geralycosa*, from Rakonitz, admits of being ably restored by the author, in whose honour it is named by Professor Kusta.

The genus *Hemiphrynus* is also well preserved in a fossil state, showing many details of its anatomy.

Promygale with 3 species has much of its structure preserved both on the upper and under side, especially in *P. elegans* from Nyran, which is honoured with a plate, 2 text-figures, and a vignette on the cover; *Kophlocus*, a long-legged spider from Nyran, shows the reproductive organs and limbs and the general form well preserved.

Anthracomartus is another well preserved type represented by 8 species; 4 from Bohemia, 3 from Germany, and 1 from Arkansas, U.S.A. This round-bodied and very distinctly segmented type is closely allied to *Brachypyge* and *Eophrynus*; in most of these forms the dorsal surface of the body-segments is ornamented by a pattern of minute raised granules. *Anthracosiro* appears not to have possessed this ornamentation on the dorsal surface.

Among the Pseudoscorpions *Prothelyphonus bohemicus*, Kusta, is a remarkably well preserved species, giving nearly every detail of its structure and its attenuated series of abdominal segments.

Good figures are also given of the Carboniferous and Silurian scorpions of Bohemia, England, Scotland, Sweden, and America, of which much has already been written in this country by Woodward, Peach, Pocock, and others.

But space does not admit of our dwelling more fully on this interesting group of terrestrial air-breathing *trachæated* palæozoic Arthropods, the direct descendants of the still more remote aquatic *branchiated* Merostomata. *Pterygotus*, *Slimonia*, *Stylonurus*, and their allies.

We congratulate Dr. Fritsch upon this interesting monograph, and wish him health and strength to pursue his studies on the fossil fauna of his beloved country of Bohemia which he has done so much to illustrate.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 22nd, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Igneous Rocks of Pontesford Hill (Shropshire)." By Professor William S. Boulton, B.Sc., Assoc. R.C.S., F.G.S.

This paper is confined to a description of the characters and sequence of the rocks within the limits of Pontesford Hill, and no attempt is made to correlate them with those of the Uriconian areas. The hill is a 'plagioclinal ridge,' bounded on all sides by faults; it is made up entirely of igneous rocks, but some of the fine tuffs and volcanic grits show unmistakable signs of deposition in

water. There are two distinct groups of igneous rocks: a bedded group, consisting of rhyolites and acid tuffs, with andesites and andesitic tuffs; and an intrusive group of olivine-dolerites. The general strike of the bedded rocks is north-north-easterly and south-south-westerly, parallel to that of the neighbouring Longmyndian rocks; the average dip is about 80° east-south-eastward, but at the extreme south-east of the hill the rhyolite and associated breccias dip in the opposite direction (west-north-westward) at about the same angle. The northern end of the hill consists of rhyolite (the 'northern rhyolite'), about 1,000 feet thick, a pale pink and purple rhyolite with much epidote, chlorite, and secondary quartz, showing vesicular, spherulitic, pyromeridal, and banded structures. Macroscopic and microscopic descriptions of the rocks are given, and the origin of the spherulitic and nodular structures is fully discussed. In many cases, though certainly not in all, the nodules appear to have begun as a vesicle, often irregular in shape, and sometimes with crescentiform spaces round the main cavity, and separated from it by similarly-shaped portions of the glass. The spherulitic fibres appear to develop, not from a central point outward, but locally from vesicles or other cavities, crystals, etc., coalescing finally to form larger and longer growths. The spherulitic type of devitrification is not all of the same age, for fibrous growths traverse small and earlier-formed spherulites, which have been dissolved out and replaced by quartz. The andesitic group is made up of felsitic-looking, gritty pink and green tuffs, passing up into and interbedded with andesitic glassy (palagonitic) and crystal tuffs, hälleflintas, and lavas; the thickness is about 1,600 feet. A thickness of about 150 feet of rhyolite-breccias (glassy and crystal tuffs) and grits succeeds; and this is followed by the south-eastern rhyolite, about 250 feet thick, a dark red or purple, coarsely vesicular, well-banded rock, often with light-green and white amygdules. The andesites consist of oligoclase and malacolite, embedded in a hyalopilitic groundmass containing palagonite, in which ilmenite, leucoxene, and magnetite are embedded. A table of the silica-percentages and specific gravities of the bedded rocks shows that a gap occurs between the 'northern rhyolite' and the more acid of the andesite-tuffs that immediately follow; this, together with a discordance in strike, may indicate a break in volcanic history, a disturbed junction, or that this rhyolite is intrusive. From this point onward, the tuffs and lavas form a continuous series, despite the difference in the average silica-percentage of the andesite group and the rhyolite-breccias. The tuffs thin out to the north-eastward, their lapilli diminish in size, and they become more gritty and washed in aspect in the same direction; facts which all point to the inference that the volcanic vent may have been to the west of the hill. The intrusive rocks are basic, and often amygdaloidal; they are granular or ophitic, and compare in composition with such olivine-dolerites as those of Rowley, the Clee Hills, and Little Wenlock, while they differ considerably from the intrusive dolerites of North Wales.

2. "The Tertiary Fossils of Somaliland, as represented in the British Museum (Natural History)." By Richard Bullen Newton, Esq., F.G.S.

Since the publication, in 1900, of Prof. Gregory's paper, founded on specimens in the Natural History Museum, mostly collected and presented by Mrs. Lort Phillips, the National Collection has been enriched by further series of fossils: the Donaldson-Smith Collection and one presented by Major R. G. Edwards Leckie. The new material is, generally speaking, better preserved than that previously dealt with. The large Lucinidæ and specimens of *Campanile* (previously considered as *Nerinæa*) are very typical of Eocene rocks generally, and they agree with the foraminifera in the Somaliland Limestones in supporting the reference of these rocks to this period. The matrices of these limestones correspond with those surrounding the corals described by Professor Gregory as belonging to the Uradu and Dobar Limestones. Two limestones seem to be represented in the collections—an upper, massive and cherty, often coloured reddish-brown externally; and a lower, of less cherty character and lighter colour. The limestones appear to be capable of correlation with those of the south-eastern corner of Arabia, as well as with those of Sind and Cutch; they can also be traced in connection with the Eocene areas of Egypt and other regions of North Africa, through Europe to the Paris Basin, and so to the Bracklesham Beds of England. The new collections contain some older fossils, but they are not considered in the present paper.

A review of the literature of the subject is given, and the author then proceeds to the description of species of gasteropods, lamellibranchs, echinoids, and corals. Six new species are described and named, and sixteen species or varieties described but not named. An account of the foraminiferal structures of the limestones follows, and the paper closes with a list of the known Tertiary fossils from Somaliland.

3. "The Caernarvon Earthquake of June 19th, 1903, and its Accessory Shocks." By Charles Davison, Sc.D., F.G.S.

The Caernarvon earthquake of June 19th, 1903, was the strongest earthquake indigenous to the county for more than five centuries. Its disturbed area contained about 25,000 square miles, and included nearly the whole of Wales, the North-West of England, the Isle of Man, and several of the eastern counties of Ireland. The centre of the innermost isoseismal (intensity 7) was situated beneath the sea, about 4 miles west of Pen-y-groes, and the longer axis of the isoseismal ran from N. 40° E. to S. 40° W. It is concluded, from the seismic evidence, that the earthquake was caused by a slip of about 16 miles in length along a fault running in the above direction, hading north-westward, and passing either through Clynnog or a mile or two either to the north-west or south-east. In the former case the fault-line might be submarine; and it is pointed out that, if the fault which runs in a south-westerly direction from Aber to Dinlle (on the coast of Caernarvon Bay) were continued